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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 8, No. 4 OCTOBER, 1936 25c a copy

Electric welders at work on piping in Ford power plant

Round Table Conferences

Modifications of the Hot Process When Conditioning Makeup for High-Pressure Boilers

Boiler Units

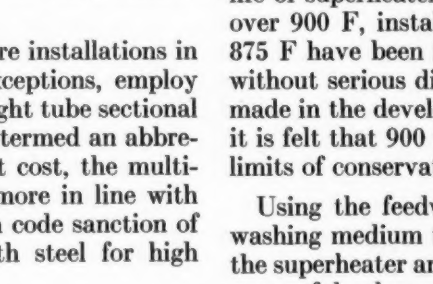
. . . *For High Pressures and Temperatures*

NUMBER FIVE of a series of advertisements in which subjects of current interest to utility engineers and consultants are briefly reviewed and present trends indicated. Subjects covered are as follows: (*1*) *Superposition;* (*2*) *Furnace Design;* (*3*) *Heat Recovery;* (*4*) *Heat Cycles;* (*5*) *Boilers for High Pressures and Temperatures;* (*6*) *Availability of Modern Boiler Units.*

THE vast difference between the modern steam generating unit and its predecessor of say fifteen years ago is mainly attributable to three developments: pulverized fuel firing, water cooling of furnace surfaces and the adoption of high pressures and temperatures. The latter development has been greatly accelerated in recent years by improvements in materials and by the perfection of fusion welding for boiler drums. Through this fifteen-year period the terms "high pressures" and "high temperatures," as used in power station practice, have undergone a drastic change in meaning. At its inception, they meant pressures in the 175–275 lb range and temperatures from 470 to 660 F. Today they are commonly used with reference to pressures from 600 to 1400 lb or higher, and temperatures from 750 to 950 F.

All of the recently projected high pressure installations in this country, with possibly one or two exceptions, employ either multi-drum bent tube boilers or straight tube sectional header boilers, the latter in what might be termed an abbreviated form. From the standpoint of first cost, the multi-drum bent tube boiler has been brought more in line with the single-drum straight tube type through code sanction of fusion welding and 70,000 tensile strength steel for high pressure welded drums.

The influence of high pressures and temperatures on overall unit design is illustrated by the accompanying chart. This shows the distribution of work among the several elements of a steam generating unit at pressures up to 1500 lb absolute in the process of converting water at 212 F into superheated steam. As the pressure increases, the area indicating work to be done by evaporating surfaces decreases. At 3226 lb absolute pressure this area would become zero, and, in effect, the unit would be reduced to an economizer and a superheater. The work to be done by the superheater is predicated on the arbitrary temperature curve shown.



Because modern high pressure units for operation at high ratings require large water cooled furnaces, the boiler surface proper is relatively small, amounting to 50–60 per cent of total evaporative surfaces. In some recent designs, heat absorption by the boiler surface proper amounts to only 20 per cent of total heat absorption.

The amount of water cooled surface in the furnace is also influenced by the fusion temperature of the ash in that it is essential to reduce the temperature of the gases entering the boiler below the fusion temperature in order to prevent excessive slagging of the boiler tubes. This presents a difficult problem where high superheat is required and the fuel has a low fusion temperature. Under such conditions it is necessary to have a relatively small amount of boiler surface between the furnace and the superheater.

The superheater itself has taken on greatly increased importance. In fact, superheater design now has considerable influence over boiler and general unit design instead of being merely an adjunct as was the case a few years ago. Better control of superheat temperature is being obtained through the use of gas by-pass dampers which have been made practicable by the development of improved materials. This arrangement permits control of the flow of gases over superheater surfaces and thereby makes possible the maintenance of more uniform steam temperature without resort to expensive and sometimes troublesome desuperheating. The result is more efficient turbine performance.

Although there is as yet no large amount of data on the life of superheater materials for total steam temperatures of over 900 F, installations using steam temperatures of 850–875 F have been in service for periods of two to four years without serious difficulty. With the progress that has been made in the development of materials for high temperatures, it is felt that 900 to 950 F steam will prove to be within the limits of conservative design.

Using the feedwater, low in concentration of solids, as a washing medium to decrease the amount of solids carried to the superheater and high pressure turbine has been uniformly successful where the "make-up" water has been a small percentage of the total. Rapid progress is being made in the successful washing of steam where 100 per cent "make-up" is used.

The construction of boilers for high pressures has presented no serious problems with respect to tube joints or other details. The use of 70,000 tensile strength steel in welded drums has permitted a desirable reduction of metal thickness. Further improvement in metal for heavy drums is being realized through the introduction of low percentages of alloying elements.

In conclusion, it may be said that while the practicability and advantages of high pressures and temperatures have been amply demonstrated, specialized abilities and extensive experience are factors of primary importance in the work of designing and fabricating the necessary equipment.

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME EIGHT NUMBER FOUR

CONTENTS

FOR OCTOBER 1936

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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EDITORIAL

New Steam Table Values in the Higher Ranges

When the first International Steam Table Conference was held in London in 1929, a wide difference in values existed as between the several previously accepted steam tables. As a result weighted averages were determined for a certain number of pressure and temperature conditions and tolerances chosen beyond which it was agreed the true values did not lie.

This was the first step toward obtaining steam tables that would be accepted internationally, but it was agreed that the investigations under way in England, Germany, Czechoslovakia and the United States should be carried forward with the aim of reducing the differences and eventually arriving at the true values.

The Second Conference abroad further reduced the tolerances and the net result of the Third Conference, held in this country two years ago, was a close agreement of the critical value, the enthalpy of saturated vapor and a further reduction in the tolerance on enthalpy of superheated steam to one-third that agreed upon at the London Conference. Moreover, a skeleton table was produced which gave new values in the range above 600 pounds and 670 degrees Fahrenheit, the values below this being in close agreement.

However, as mentioned by George Orrok at the recent Philadelphia Round Table Conference, subsequent researches showed these skeleton tables to run a little high in the upper ranges—as much as 18 Btu at 1800 pounds and 1000 degrees, and 12 Btu at 900 degrees, although about right at 600 degrees. At other pressures in the higher range the differences were proportional. New steam tables by Dr. Keys and Professor Keenan of Massachusetts Institute of Technology incorporating these changes are now in press.

In view of the present trend toward higher temperatures, and in many cases higher pressures as well, the corrected values are most important.

"Tailor-Made" Installations

Usually when engineers gather to discuss present trends in power station design and practice, comment is frequently heard to the effect that practically all the new important installations are "tailor-made" and that initial costs could be reduced materially were some degree of standardization adopted.

As regards the larger installations, particularly those for high pressures and temperatures, it is obvious that never are the conditions pertaining to any two stations identical and seldom similar. Furthermore, there are so many factors entering into the most economical design for each particular set of conditions that individual treatment becomes necessary, especially where space limitations must be met. Also, if progress is not to be impeded practice must push forward. It is quite true that engineering expense may thereby be increased but, as a rule, in the larger installations engineering costs form a relatively small part of the total cost and any increase in this item is likely to be more than offset by the operating savings incident to having arrived at the correct solution for the given conditions.

Whether so-called "tailor-made" layouts are justified in the case of many installations of medium size, pressure and temperature came up in the discussion of Mr. Powell's paper at the recent Niagara Falls Meeting of the A. S. M. E. The majority of these installations do not necessarily involve pioneering problems, such as concern many plants of the first group, and it was felt that simplification of the present variety of operating conditions would be most advantageous. It was further suggested that such plants be designed for wider latitude both as to fuel and operating conditions, for seldom do these factors remain constant over the useful life of the equipment. Moreover, increased engineering expense in such cases usually forms a proportionately greater part of the total initial cost.

Following the logic of this contention, progress need not be impeded, for the experience gained through pioneer work in the few stations could later be applied generally. Meanwhile, as one discussor said, it may be well to cash in on the experience for one cycle of development at a time.

High-Speed Hydrogen-Cooled Turbine-Generators

Orders recently placed for two 60,000 kw turbine-generators to operate at 3600 rpm mark a further step in the employment of high rotative speeds for large units, for until a year or two ago such speeds were confined to comparatively small units.

This has been made possible by the development of hydrogen cooling for the generators. The hydrogen, because of its very much lesser density, reduces the friction and windage and results in increased generator efficiency.

While these higher rotative speeds are especially desirable for high-pressure machines where it is advisable to keep down the diameter of the rotor, units have also been sold to operate at medium pressures condensing. Abroad the largest high-speed turbine-generator now in service is rated at 80,000 kva and rotates at 3000 rpm.

There are building or on order in this country seventeen 3600 rpm units of various capacities from 12,500 to 60,000 kw and it is understood that turbine manufacturers are prepared to build still larger sizes. This is indeed a tribute to the extensive development work that has been carried on over a period of years to bring about the success of hydrogen cooling.

ROUND TABLE CONFERENCES

Discuss

Welded Boiler Drum Practice
Cleaning Stack Gases
The Mercury Boiler
Materials for High Steam Temperatures
So-Called Special Boilers
The Once-Through, Forced-Circulation Boiler
Control of Superheat

As PART of the technical program of the World Power Conference, Round Table Conferences were held in connection with the four Technical Study Tours. The Group on Tour III, which visited outstanding steam plants in the East and as far West as Chicago, held Round Table Conferences at Pittsburgh on September 4 and at Philadelphia on September 24. At each of these, separate sessions dealt with steam, electrical and management subjects, respectively. The Pittsburgh session on steam topics was presided over by E. D. Dreyfus, of the West Penn Power Company, and the Philadelphia session by N. E. Funk, Vice President of the Philadelphia Electric Company. Following are abstracts of the papers which opened the discussions on the selected topics, together with a digest of the discussions:

Welded Boiler Drum Practice

At the Pittsburgh Round Table Conference on September 4, **E. R. Fish,** Chief Engineer of the Boiler Division, The Hartford Steam Boiler Inspection & Insurance Company, attributed growth of welded drum construction to the trend toward higher steam pressures and temperatures, for even with relatively small drum diameters plate thicknesses approached the practical limit for riveted construction which is about 2 in. Also, the demand for large capacity units necessitated very long drums for which riveting was impracticable. He reviewed the transition stage of forged drum construction which, because of the expense involved, gave way to fusion welding as soon as it was demonstrated to the satisfaction of the A.S.M.E. Boiler Code Committee that this practice, with certain prescribed safeguards, was acceptable. This was just five years ago and today the substitution of welded for riveted or seamless construction has become general for moderate as well as for high pressures in this country. Plates up to 5 in. thick and 35 or 40 ft long are now pressed and welded.

Not only are the seams welded but it is also the practice, under carefully prescribed rules, to attach by welding the outlet nozzles and any needed reinforcement.

He pointed out that riveted joints in boiler drums have always been subject to leakages and other troubles such as cracking between rivet holes, which have caused many major failures. On the other hand, welded drums are absolutely tight and there are no discontinuities to cause concentrations of stresses of unknown distribution and magnitude. Boiler insurance companies are strong proponents of welded construction and do not hesitate to afford insurance on boilers of this type. Moreover, there is little difference in the relative costs of riveted and welded construction.

Although the A.S.M.E. Boiler Code does not sanction the welding of other than the cylindrical parts of a boiler, it now has a sub-committee charged with the study of the extension of welding to other features of boiler design such as staybolts, water-wall and superheater tubes, braces, etc.

A. J. Moses, of the Hedges-Walsh-Weidner Division of Combustion Engineering Company, at Pittsburgh discussed welded boiler drum practice from the standpoint of accepted materials, methods of construction and present trends. At present the A.S.M.E. Boiler Code approves the use of two grades of modified carbon steel of 65,000 and 70,000 lb per sq in. minimum tensile strength, these steels differing from the 55,000-lb firebox steel in that the carbon and manganese contents are higher, being limited to 0.35 per cent and 0.9 per cent, respectively. These steels are now in general use in the construction of welded high-pressure boiler drums.

Boiler plates up to 5-in. thickness are now being employed and where the thickness exceeds 2 in., a normalizing heat treatment is applied to the flat plates

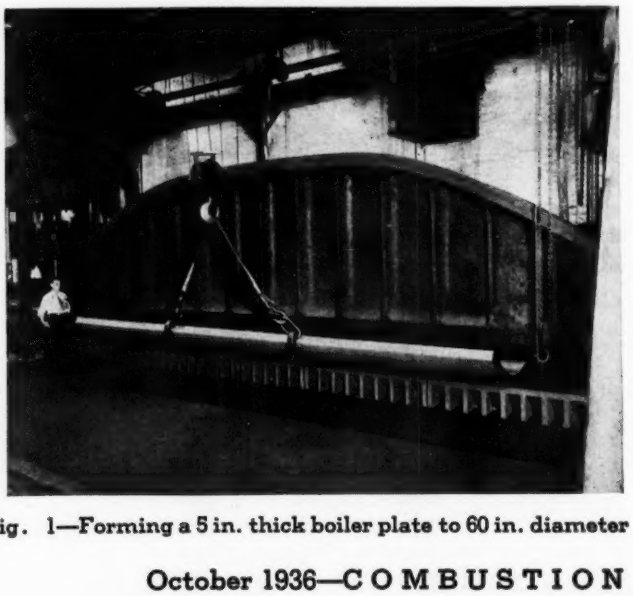


Fig. 1—Forming a 5 in. thick boiler plate to 60 in. diameter

before forming, for grain refinement. Also, a subsequent drawing treatment is sometimes given to facilitate the forming operation when this is performed cold. The shaping of these heavy plates is done under hydraulic pressure, and this necessitates two longitudinal seams. Since intermediate girth seams are not desirable the shells are composed of two plates each formed to approximate half circles. Shells exceeding 40 ft in length have been thus constructed.

Plates of unequal thickness are frequently employed in such drums, the heavier section being designed for areas to be perforated with tube holes and the lighter plate for unperforated sections or those having greater tube hole ligament efficiency. In such cases the heavier plate is tapered by machining to the thickness of the lighter plate. This planing, together with machining of the weld grooves, is usually done after the plates have been formed into half cylinders.

The electric metallic arc method of welding with heavily coated electrodes about $^1/_4$ in. diameter is the accepted practice. Fillet welding is permitted only in the welding of nozzles, reinforcements and attachments. All welding is done in the down-hand position, the drum being slowly rotated to accomplish this when the heads are being welded to the shell. The weld metal is deposited in the grooves in relatively thin layers. Inasmuch as the process leaves a heavy slag coating over these layers it becomes necessary to clean thoroughly the slag from each layer before depositing the succeeding layer.

In finishing double-butt welds a small reinforcement of deposited metal is added to both sides of the plate and this is subsequently chipped off and the surfaces ground practically flush with the plate. With longitudinal seams, attached samples continuous with the joint are welded for checking against standard requirements.

Following the X-ray examination, completely welded drums are thermally stress-relieved, the drums being gradually brought up to a temperature of 1100 to 1250 F, held there for an hour per inch of thickness and the furnace cooled to about 500 F before removal.

At present there is a demand for a reliable and economical extension of non-destructive testing to greater thicknesses and also for the approval of higher tensile steels. Some very promising preliminary fatigue tests have already been made on welded vessels fabricated of special steels of tensile strengths up to 85,000 lb per sq in. minimum. Present data indicate that limitations in this respect will have to do with ductility requirements of the base materials.

Dr. D. S. Jacobus, Advisory Engineer of Babcock & Wilcox Company and Chairman of the A.S.M.E. Boiler Code Committee, opened the discussion on this topic at Philadelphia. He reviewed the successive steps leading to the formulation of rules for fusion welding by the Boiler Code Committee and tests conducted to verify or assist in establishing certain provisions.

The matter was first brought before the Committee in March 1920. The first set of rules, promulgated in 1927, as limited in its application to unfired pressure vessels and specified low working stresses for the fusion welded joints. Subsequent tests that demonstrated the dependability of properly made fusion welds, and the development of suitable X-ray apparatus to permit the examination of joints in steel plates up to 3 in., led to the publication in 1930 of proposed specifications for the fusion welding of drums or shells of power boilers and shortly thereafter a complete review of the rules for fusion welding of unfired pressure vessels. The rules affecting boiler drums and shells were adopted in July 1931. These rules do not cover all parts of boilers that might be fusion welded, but special rules have been and are being added from time to time to cover more fully all types of construction.

In formulating the A.S.M.E. Boiler Code rules for fusion welding every precaution was taken to secure safety and all welds are required to be stress-relieved at a temperature of from 1100 to 1200 F for a period proportioned on the basis of at least one hour per inch of thickness. This eliminates a troublesome element involved in the A.S.M.E. Unfired Pressure Vessel Code and in other codes covering unfired pressure vessels, such as the Joint A.P.I.-A.S.M.E. Code for Petroleum, Liquids and Gases which sanctions the building of certain vessels without stress-relief and makes it necessary to provide rules to cover the vessels that need not be stress-relieved. The method of examination of welded joints by the X-ray has been a major factor in securing safety and in establishing confidence in the use of welded boiler drums.

To give an idea of the rapid acceptance of fusion welding, which has practically supplanted riveted construction during the last five years, Dr. Jacobus quoted figures from eleven companies showing that approximately 7000 boiler drums and pressure vessels have been fabricated in which the main joints were X-rayed. These represent about 800,000 linear feet of welded joints in shells ranging up to $4^7/_8$ in. in thickness. In the Boulder Dam project, 270,000 ft of film was used for the examination of the joints in the welded penstocks.

The use of higher tensile strength plate has been increasing. While plate of 55,000 lb per sq in. minimum strength has long been standard for stationary boiler construction now a large amount of 70,000-lb plate is being used, particularly for high-pressure drums. This is an open hearth silicon-killed steel with slightly increased carbon content. A weight saving of a little over 25 per cent may thus be obtained.

German practice as explained in a paper by **Dipl. Ing. E. Lupberger,** Director of the Association of Owners of Large Boilers, Berlin, has practically discarded riveted drum construction for new boilers. For pressures up to 850 or 900 lb, gas or electrically welded drums are usually employed, whereas for pressures in excess of this forged drums, of steel having a tensile strength up to 100,000 lb per sq in. are employed. Because of this high tensile strength, thinner wall thickness, hence lighter drums, are possible. Forged drums up to 66 in. diameter and 60 ft long have been made.

It is customary not only to stress-relieve the welded drums at about 1100 F but to normalize them at about 1700 F. They are being made of low-carbon steel or an alloy steel containing 0.3 per cent molybdenum and of 70,000 lb per sq in. tensile strength. Fusion-welded drums are usually subjected to X-ray examination, the X-ray tubes being placed within the drums in order to have the rays normal to the plate. Gamma radiation is also employed to some extent and magnetic powder is used to detect small cracks. X-ray voltages up to

200,000 are available. Furthermore, all connections to high-pressure drums are made of small diameter and in multiple, where required, so that reinforcement is not necessary. Welding is applied to connections only as a means of securing tightness and not for strength.

Cleaning Stack Gases

M. D. Engle, of the Edison Electric Illuminating Company, of Boston, reviewed practice in this country in scrubbing stack gases. If properly installed, gas scrubbers should recover at least 90 per cent of the solids in the flue gases. Unfortunately, test methods have varied so widely that it is difficult to compare the relative efficiencies of the various types. In view of this situation the Power Test Codes Committee of the A.S.M.E. is now engaged in drawing up a code for testing such devices.

One company manufacturing a wet-plate type scrubber has nineteen installations in service and reports efficiencies of 90 per cent at full load and somewhat less at lighter loads. In this design the gases are not saturated but are split up into a large number of thin parallel streams which are subjected to abrupt changes in direction between the wet scrubber plates. All parts coming in contact with the gases are of acid-proof brick or other non-metallic materials. The wet plate design has a rising efficiency curve giving the highest collecting efficiency at the time of the greatest gas flow and, consequently, at the time of maximum discharge of solids from the boiler uptake.

A second type of scrubber which Mr. Engle described (see Fig. 2) employs the recirculation principle as applied to the scrubbing water. The gas is saturated, to obtain the maximum wetting of the dust particles, and the mixture is subjected to violent centrifugal action by means of a tangential gas inlet, after which straightening vanes in the gas exit reduce the pressure drop. These scrubbers are designed for a draft loss of $1^1/_2$ in. of water and require $1^1/_2$ to 2 gpm of water per cubic foot per minute of gas scrubbed. Several installations are in operation and the test efficiencies reported range from 82 per cent at full load to 98 per cent at light loads, the higher efficiency at light load being accounted for by the fact that the volume of scrubbing water remains constant.

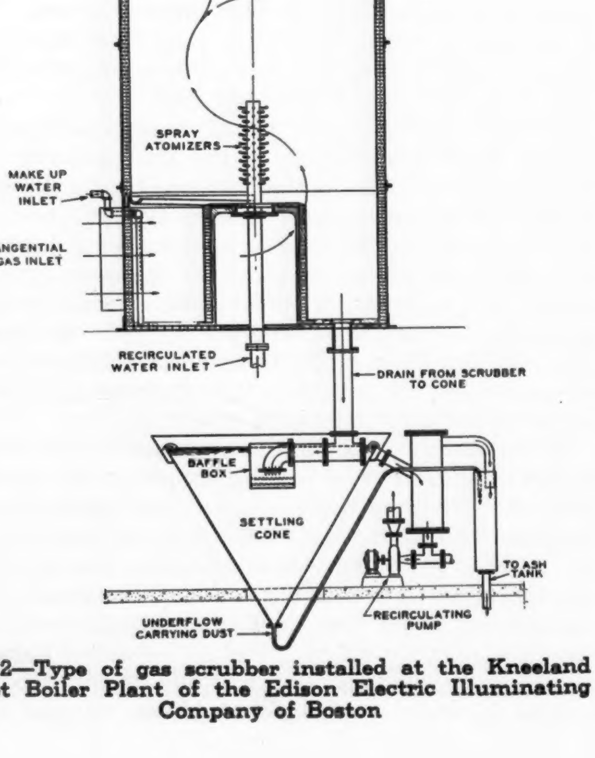


Fig. 2—Type of gas scrubber installed at the Kneeland Street Boiler Plant of the Edison Electric Illuminating Company of Boston

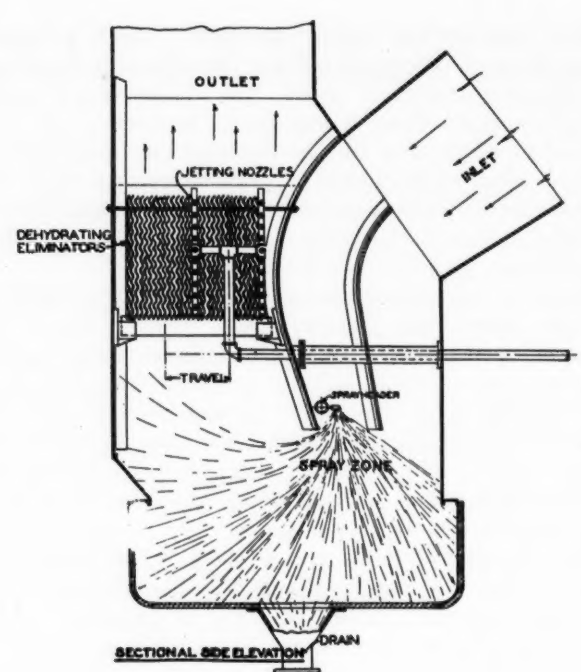


Fig. 3—Spray zone fly-ash eliminator installed at Hell Gate Station, New York

A spray type of scrubber, as shown in Fig. 3, has been developed and installed at the Hell Gate Station in New York for cleaning gases from a 400,000 lb per hr pulverized-coal-fired boiler and has been in service four years. Efficiencies of 90 to 97 per cent are reported at all loads. This efficiency is especially noteworthy inasmuch as only 0.6 gpm of scrubbing water per 1000 cfm of gas is used and the pressure drop is very moderate.

Commenting on the maintenance of gas scrubbers, Mr. Engle pointed out that while the scrubbing water is only slightly acid it is very corrosive to all metal parts. Acid-proof brick set in acid-proof cement, chemical stoneware and glass have proved satisfactory where they can be used. Rubber-lined pipes and pumps have performed well for several years but eventually wear out. Hard rubber resists the corrosive action best but soft rubber better resists the erosion of the solid matter. Nozzles for scrubbers using recirculated water have been made of heat-treated lava and have stood up very well despite its brittleness. Certain synthetics such as the phenol formaldehyde groups have shown excellent resistance to corrosion but will not withstand high flue gas temperatures, should the scrubbing water fail; also they are not resistant to severe corrosion.

Herman Hellmich, Dir. Elektricitatewerk Südwest, Berlin, in a paper on this subject, stated that electrostatic precipitators are extensively used in Germany to collect the fly ash from pulverized coal installations

but because of their high cost attention is now being directed to the wet process. Its application depends, however, largely on the possibility of purifying the refuse water. With a suitable arrangement of spray nozzles the water consumption amounts to 22.6 to 75 gal per 1000 cu ft of flue gas and can still be further reduced by applying recirculation. The combination of preliminary dry elimination with the wet process offers many advantages.

In the Finow dust extractor, developed as the result of tests at the Kaiser Wilhelm Institute, the dust particles in the gas are whirled against water-sprayed baffle walls and from here carried by the water film. The water consumption is only 3 to 3.75 gal per 1000 cu ft of gas at 80 per cent dust extraction and at 15 gal per cu ft of gas, 98 per cent of the dust has been extracted. It is important with this type that with partial loads sufficient velocity of the gas in the extractor be maintained to keep up the whirling effect. This is obtained by dividing the separator into a number of parallel cells which can be shut off as required.

Wet mechanical extraction of the flue dust cannot be applied successfully if the fly ash is susceptible to packing, as is the case with German lignites. In such cases the dry method must be used.

In connection with the guarantee tests for dust removal, thorough investigations have been made regarding the effects of the ashes in the furnace. The result was that the figure of the ash-balance was always incorrect since the mineral components of the coal have no heat resistancy and since their weight varies through dissociation, oxidation or reduction or by elimination or absorbtion of gaseous constituents. Owing to the ash contents in the fuel being dependent on the temperature, guarantee tests can be made only by direct measurements, i.e., the measurement of the gas dust, of the pure gas and the weighing of the separated dust will show the best results. By this method an accuracy of ± 1 per cent may be attained.

An important source of errors in the measurement of the dust is the fluctuation of the operating conditions, of the load and of the firing and the changing quality of the coal with regard to ash contents and the granulation. Also the distribution of the dust contents within the gas channel will not always correspond to the velocities. If time-wasting checking tests are to be avoided, there must be at least a sufficient number of measuring points and a simultaneous tapping off at several points in short periods.

Since the principal question is to reduce the nuisance through dust in the surroundings to a certain degree, the partial dust extraction figure affords real judgment on a separator. It is gradually becoming practice to measure the degree of extraction by the velocity of fall. This takes into consideration the form of the dust grain and the specific weight, which are the factors that designate the amount of dust nuisance.

Concerning the legal status of property of third parties affected by smoke or flue dust, according to German law the owner of real estate has to put up with the effects of smoke and flue dust caused by third parties in case they are unimportant and locally customary. Whether the effect is important or unimportant is a mere question of fact which can only be answered according to the circumstances. The local customs are judged by the local circumstances, it being assumed that other real property near the plant is used in the same or similar manner. In case it is locally customary, the owner of the afflicted real estate property has to put up with even annoying influences. Considerable annoyance by smoke and flue dust in an industrial district is, therefore, not an admissible influence, according to law, while a much less annoying inconvenience may be prohibited in case it originates from a factory situated in a non-industrial district, or is situated in a residential district. In such a case, an owner can sue for damages, requesting the removal of the nuisance and the stopping of further annoyances; the factory may also be ordered to stop operation, or the removal of the disturbing part of the factory is ordered, if the nuisance cannot be removed in any other way.

The rights of the owner of affected property are considerably restricted if the annoyance is caused by a factory erected with government permission. In such cases the owner of the afflicted real estate property has to suffer the influences from third parties beyond the extent permitted by law, where no remedy is possible, or interference would be detrimental to the regular operation of the plant.

In the subsequent discussion, following the papers by Mr. Engle and Mr. Hellmich, the opinion was general that reported efficiencies do not mean very much because of the absence of a standard by which the performances can be compared.

The Mercury Boiler

Discussing the "Generation of Power from Mercury

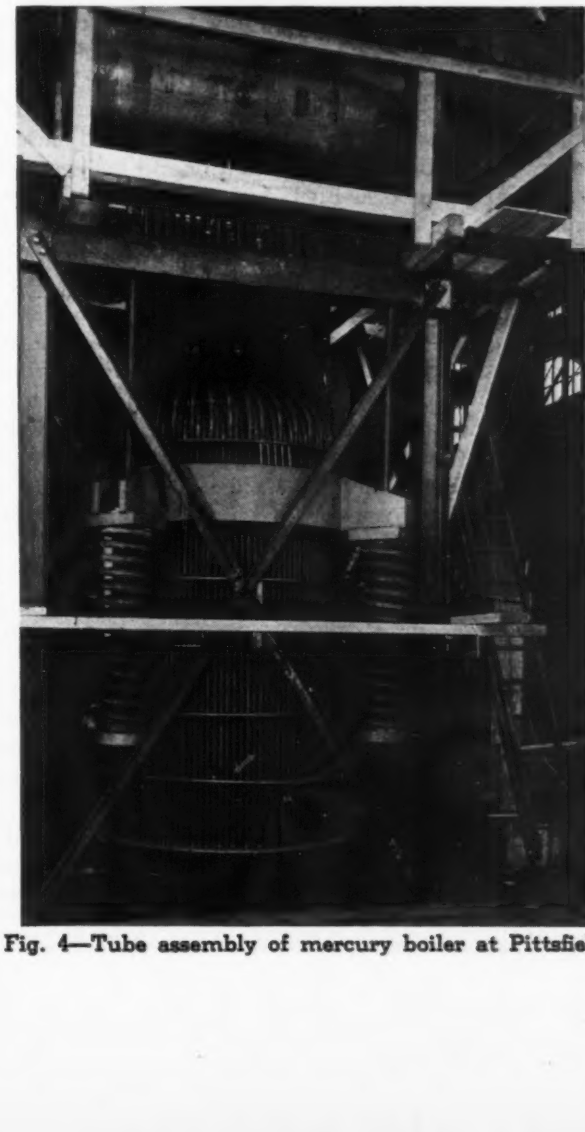


Fig. 4—Tube assembly of mercury boiler at Pittsfield

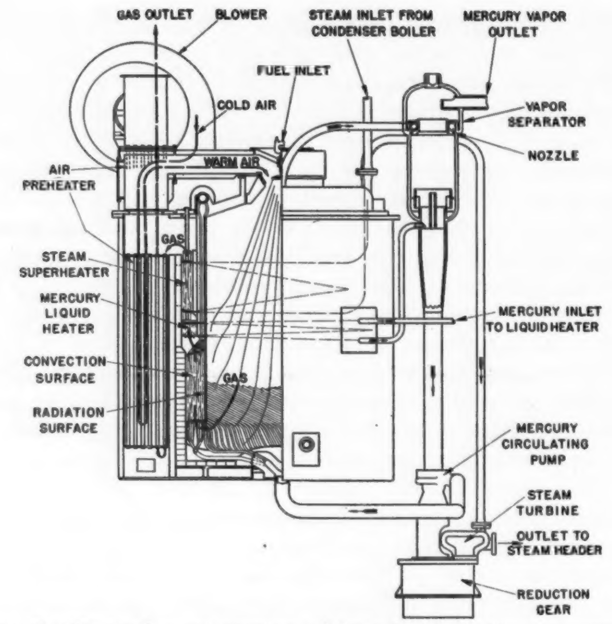


Fig. 5—Vertical semi-section of forced-circulation mercury boiler at Lynn

Vapor," **A. R. Smith,** of the General Electric Company, after briefly commenting on the existing installations at Hartford, Schenectady and Kearny, told of two new, but smaller, units that have been built—one for use in its Lynn Works and the other for its Pittsfield Works. These embody important modifications in design resulting from experience with the earlier installations mentioned. In each of these smaller units the mercury turbine is of 1000-kw capacity and the 12,500 lb of steam per hour supplied by the condenser boiler at 185-lb gage will be sufficient for the generation of another 900 kw of electric energy.

The boiler at Pittsfield (see Fig. 4) is of the natural circulation type with tubes similar to the liquid mercury cooling walls in the boilers at Kearny and Schenectady. The unit at Lynn (see Figs. 5 and 6) is of the forced circulation type with all the heating tubes filled with liquid mercury and all the vapor formed in a separate chamber remote from the combustion space. The vapor is generated by discharging from the heating tubes through a nozzle which drops the pressure and releases the stored heat of the liquid, a portion of which flashes into vapor, the pressure in the heating tubes being approximately 200 lb per sq in. greater than that in the flash chamber. This arrangement was evolved to eliminate the transition zone in the combustion space, from liquid to vapor, in which difficulty in "wetting" the metal surfaces had been encountered.

Reviewing the operating difficulties experienced in the earlier installations, Mr. Smith classed these under four general headings, namely, leakage, equalization, air infiltration and solubility.

The possibility of leaks, even in minute quantities, has necessitated constant surveillance of the stack gases and every such indication necessitated an immediate shutdown. However, these difficulties have been now overcome by progress in welding.

The avoidance of excessive investment requires maintenance of a low liquid level in the seven drums, and in order to make sure that no drum will fail to feed its porcupine tubes, it has been necessary to provide for careful maintenance of levels and adequate communicating passages have been necessary. A simpler boiler with only one drum has now been designed to overcome these objections.

Another source of difficulty has been occasional overheating of certain tubes due to non-wetting by the liquid. This was the result of air infiltration and contamination of the mercury by oxide formation. Deoxidating agents introduced into the mercury remedied this non-wetting condition but caused lumping of the products of oxidation so as to stop up some of the tubes. Now, however, a design of liquid mercury shaft packing has been evolved which has zero leakage and in the Schenectady plant the air infiltration from all sources has been reduced from 200 or 300 cu ft per hr to less than 1 cu ft per hr.

While there have been no shutdowns due to the tendency of the mercury to dissolve the materials, laboratory investigations have proved that solution of the steel may be inhibited by certain agents, as a result of which small quantities of zirconium are now being added to the mercury.

Design sketches, Fig. 7, for a mercury-steam installation of 44,000-kw capacity were shown. This employs a single drum. Moreover, there are no dead-ended porcupine tubes, which are difficult to clean, and no water walls in the furnace, the latter being cooled with liquid mercury tubes, in the upper lengths of which vaporization occurs. In the upper and cooler part of

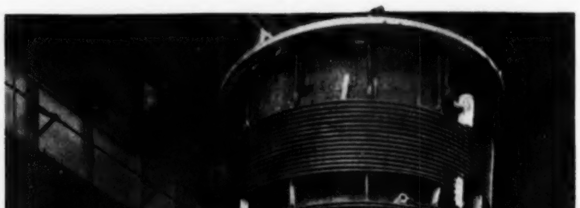


Fig. 6—The Lynn mercury boiler showing firebox, convection tubes, liquid heater and steam superheater before lowering into casing; outlet of air heater at upper left

[1] Mr. Smith presented his paper in person at Pittsburgh and at Philadelphia it was presented by L. A. Sheldon of the General Electric Company.

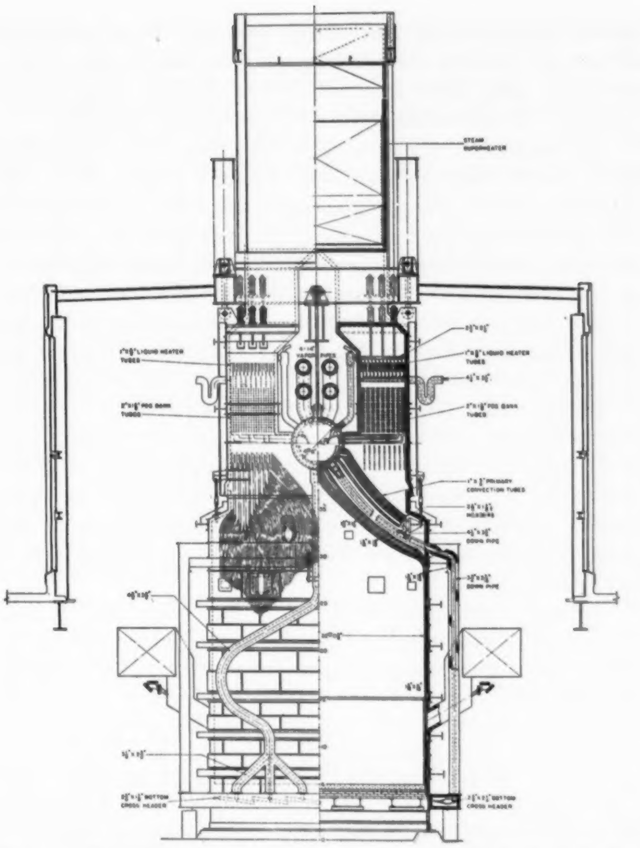


Fig. 7—Assembly of mercury-steam unit designed for 44,000 kw

the combustion chamber are arranged a series of fog bank tubes from which the products of combustion pass through a liquid heater before reaching the steam superheater and air preheater on their way to the stack.

It was stated that at Schenectady and Kearny $7^1/_2$ lb of mercury are required per kilowatt of capacity, whereas the new designs require about 6 lb. The Kearny guarantee was 9500 Btu per kwhr.

Materials for High Steam Temperatures

E. W. Norris, of Stone & Webster Engineering Corporation, leading the discussion on this subject, dealt with the effects of higher fluid temperatures on the design of piping and piping connections as reflected by current practice.

"Higher temperature operation introduces the so-called creep phenomena which require special treatment in design and a technique which is, as yet, not fully developed," he said. For design work the effect of creep is assumed to be a function of temperature, stress and time. Creep in tension is assumed to take the form of a continuous extension which is approximately uniform after the first period of relatively rapid elongation is past. This applies to conditions of uniform stress and temperature and to materials that are not affected in structure by the conditions. For parts such as bolts in flanged joints, where the stress is reduced by progressive elongation, the reduction in stress correspondingly checks further elongation. In this case the elongation due to creep approximates a logarithmic function of time within certain limits of error.

Tubular material is affected by creep in a somewhat curious way in that its permanent elongation, both longitudinal and circumferential are modified and probably materially reduced due to the interaction of the internal stresses. For this reason provision for a permanent increase in the length of pipe lines may be less than the values represented by tension creep values. The increased expansion produced by higher temperatures and the corresponding increased requirement for flexibility demand careful attention. Here the effect of creep is to relax the flexural stresses so that, regardless of how the pipe is initially assembled, that is, whether or not it is given initial springing, it will eventually reach a state of relatively low stress under normal operation. The complimentary effect is that when taken out of service, the cooling causes contraction which reverses the stresses and produces higher flexural stress in the cold condition than those existing under normal hot service. This relieves in considerable degree the piping from flexural stresses at times when internal pressure and creep conditions make it difficult to resist them and transfers these stresses to those times when they can be dealt with most easily. This suggests that for such systems it is desirable to cold spring the piping during erection.

As to welded piping and connections, Mr. Norris observed that while this is gaining rapidly in popularity, its technique is one of general application and not peculiar to high-temperature service. However, bolted connections, some form of which will probably be used for a long time to come, are affected by recent advances in practice toward higher temperatures. The flanges and pipe are not joined with sufficient rigidity to permit the transfer of a material amount of flexure from the pipe into the flanges. These act merely to produce a uniform pressure against the back faces of the flared pipe. The flexural stresses which are transmitted through the pipe wall to the joints modify the contact face pressure or gasket pressure, reducing it on the tension side and increasing it on the compression side of the neutral axis. At any point on the gasket contact surfaces the sum of the resultant forces on the gasket face plus the force transmitted by the pipe wall, must equal the force delivered by the flanges. These forces are the product of the contact areas and pressures. Referring to Fig. 8, which is a cross-section of the well-known Van Stone joint, the various parts and forces are indicated to clarify the foregoing statement.

Therefore, in designing a joint of this character, the type and size of gasket are determined and the necessary gasket pressure is fixed. The section modulus of the gasket contact faces is calculated. The maximum unit joint pressure necessary to withstand the greatest moment that can be transmitted by the pipe is next calculated and is added to the joint pressure necessary to maintain fluid tightness. The sum of these is the minimum average joint pressure that must be maintained by the bolted flange over the useful life of the joint. In addition to these forces the bolts must carry the stress due to the internal fluid pressure.

An alternative arrangement is that of the well-known Sargol joint, Fig. 9, in which the edges of the flared pipes are seal-welded. This produces a tight joint without the necessity of exerting sufficient contact pressure to maintain gasket tightness, permits the use of large diameter contact faces and appears to be well adapted to high temperature service. However, because of the limited number of high temperature in-

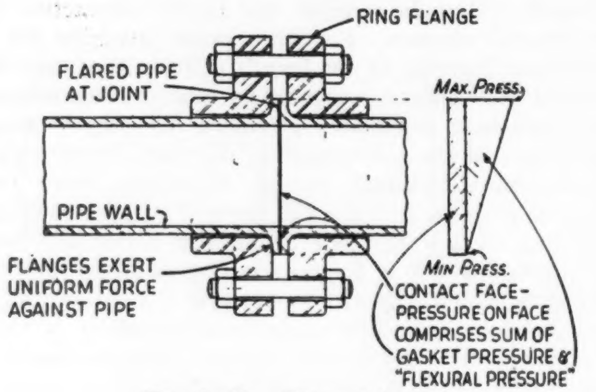


Fig. 8—Van Stone joint

stallations yet in service, experience is necessarily limited.

Dipl. Ing. E. Lupberger, of Berlin, discussed high-temperature materials with particular reference to superheaters. For temperatures up to 800 F copper-molybdenum steel, containing 0.3 to 0.5 per cent copper and a like percentage of molybdenum, is being employed in Germany. For temperatures of about 850 F copper-molybdenum steel is ordinarily used for the first section and for the second, or higher-temperature section, chromium-molybdenum steel containing 0.15 per cent Cu, 0.3 to 0.5 per cent Mo and 0.8 to 1.0 per cent Cr is employed. For steam temperatures exceeding 850 F, particularly with high flue gas temperatures, all superheater elements are of chromium-molybdenum steel. While in a few instances superheater tubes have been used containing about one per cent silicon and aluminum, austenite steel has not yet been used for superheaters in Germany.

Superheater tubes are being rolled into the headers. In some cases special rings are rolled into the tube seats to insure a perfectly steam-tight fit. For every 4 to 6 tube holes, one hand hole is provided.

In order to permit satisfactory rolling, the headers are of steel having a greater hardness than the tube. The steel for headers at 70 F has a yield limit of about 4300 to 7000 lb per sq in. higher than that of the tubes. For copper-molybdenum steel having a yield limit of 40,000 to 43,000 lb per sq in. one uses headers having a yield limit of 50,000 to 57,000 lb per sq in. With tubes of chromium-molybdenum, steel headers of the same material are used, but with a somewhat higher content of carbon or silicon in order to increase the yield point. Superheater supports subject to tension are of steel with higher chromium content.

It is interesting to note that in the two first high-pressure installations in Germany which employed steam temperatures of around 880 F, one had a superheater with carbon steel tubes and the other employed 3 per cent nickel-steel tubes. These superheaters were replaced only after from 20,000 to 25,000 hr of service because the tube diameters had increased greatly.

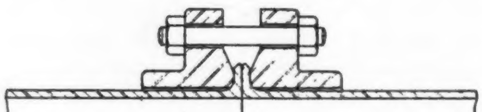


Fig. 9—Sargol joint

Operating experience, according to Mr. Lupberger, has shown that superheater failures occur more frequently where the gas passages are wide. Apparently the greater volume of gas cools less and the adjacent superheater elements are heated more than the others. A further source of trouble is the effect of sulphur-containing ash penetrating into cracks in the scale; the more the ash corrodes the tube the greater becomes the stresses and the corrosive action of the ash is increased.

Within the superheater tubes, especially at high temperatures, dissociation of the steam takes place, the oxygen combining with the metal to form Fe_3O_4 which is deposited in the tube as a brittle, blue-black mass. This causes a rise in the temperature of the tube wall and the formation of scale on the outside is accelerated.

German superheaters as well as boiler tubes have very thin walls about one-half American practice, the alloy steel tubes being computed by means of the following formula:

$$t = \frac{\frac{p\,d}{200\,s}}{1.8} + 1\text{ mm}$$

where t = thickness of wall in mm
p = steam pressure in atmospheres
d = inside diameter of tube in mm
s = yield limit at 750 F in kg per sq mm

The tubes, therefore, have a safety factor of only 1.8 at 750 F. This method of computing tubes has been in use since 1931 and no failures have been noted.

Because of the thin walls the material of alloy steel tubes for high pressures is carefully worked during the rolling process and more of the ingot heads can be cut off because for each tube less steel is required. For boiler tubes to operate at over 1000 lb per sq in. and for superheater tubes over 850 F, the ingots are cut off considerably at both ends and then machined so as to be free from slag and blow-holes. The rejections have been less than one per cent. For alloy steel tubes the mills guarantee the following properties:

Steel	Yield at 930 F	Creep Limit at 930 F
0.3 Mo	18,600 lb per sq in.	13,000 lb per sq in.
0.3 Mo + 0.8 Cr	25,800 " " " "	23,000 " " " "

Discussing flanges, **Mr. Lupberger** stated that his association had carried out many tests and experiments in order to find a reliable method for computing the dimensions of flanges. For this purpose standard flanges of 6 and 8-in. diameters were subjected to high pressures and the stresses in both the flange and the stud bolts were measured. Other tests were made with temperatures up to 1100 F and steam pressures up to 2200 lb whereby the total force necessary to keep gaskets of different types steam-tight has been measured. It was found that for high pressures and temperatures gaskets of soft iron, having a concentric serrated surface, gave the best results. For temperatures of 930 F the bolts should exercise a pressure twice that of the steam in order to secure steam-tight connections.

K. Baumann, Chief Engineer of the Metropolitan Vickers Company, Manchester, pointed out that above 900 F steam temperature the permissible stress rapidly

reduces and his experience has indicated a reduction of about one-third in the permissible stress when the temperature is increased from 900 to 965 F. He cited tests carried out in England which indicated that, above 900 F the creep strength of 1 per cent chromium steel is less than $^1/_2$ per cent molybdenum steel containing no chromium.

The Once-Through, Forced-Circulation Boiler

In a paper presented at the Pittsburgh Meeting, **A. A. Potter,**[2] Dean of Engineering Purdue University, described the once-through high-pressure experimental boiler at Purdue and discussed the high-pressure steam research being conducted by means of this unit.

This boiler is of the two-circuit forced-circulation type, oil fired and equipped with automatic control employing the thyraton tube as the source of power for the elements which regulate the supply of fuel, air and water. The minimum operative capacity is about 1700 lb of steam per hour and the maximum about 4500 lb per hr the latter being limited by the pressure drop through the tubes and the high exit gas temperature. This pressure drop becomes excessive at steam pressures below 2000 lb per sq in. except at low outputs—a limitation which could be overcome by arranging the heating surface in four instead of two parallel circuits. The unit can be brought up to normal operation from a cold state in 15 minutes, and at any given output and throttle pressure, the final temperature can be changed at will between the limits of the saturation temperature and the safe operating temperature of the tube material.

The construction of forced-circulation, high-pressure steam generators of large capacity requires the use of a number of parallel circuits connected between the intake and discharge headers. One of the fundamental problems involved in the design of such a generator is the control of the flow through the parallel circuits in order that the flow in each circuit will be stable and the enthalpy of the fluid discharged from any individual circuit may be close to that of the average. Therefore an investigation was undertaken at Purdue to determine the effect of unequal heat absorption, unequal circuit resistance and the location of equalizers.

A rational solution of this problem requires a knowl-

[2] Dean Potter's paper was presented by R. J. S. Pigott.

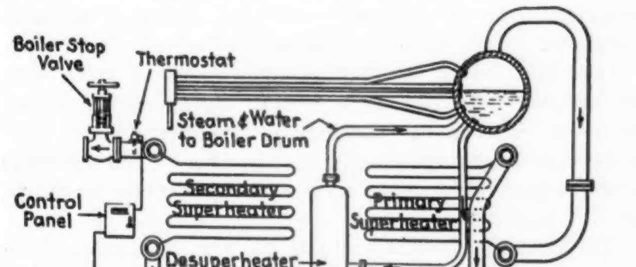


Fig. 10—Diagram of desuperheater connections and control

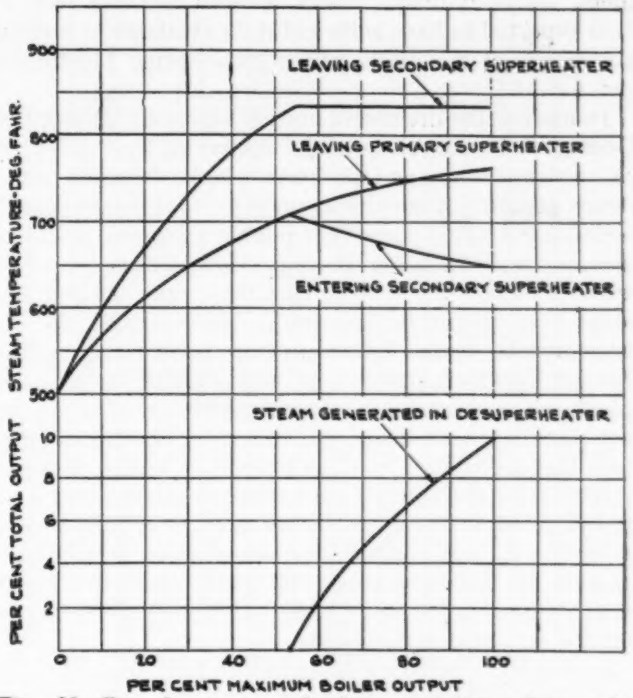


Fig. 11—Superheat control characteristics when using desuperheater as in Fig. 10

edge of the viscosity of the steam and the water for which purpose a special viscometer was developed and it was found that between 200 F and 706 F (the critical temperature) the viscosity of the saturated water may be expressed by the equation:

$$\mu = \frac{-2.185}{1 - 0.04012t - 0.0000051547t^2}$$

where μ is the viscosity in centipoises and t is the Fahrenheit temperature.

Calculations employing basic data indicate the following as to the flow distribution between parallel circuits connected into common inlet and discharge headers in a once-through, forced-circulation steam generator:

1. The flow under such conditions is inherently unstable and the pressure drop is nearly independent of the flow rate. Slight variations in heat transfer rates or functional resistances may result in decreased flow and burned out tubes when several such circuits operate in parallel.
2. The flow in unstable circuits can be stabilized by employing resistors such as small-diameter tubes at the inlet ends, although this will increase the work of the feed pump.
3. The use of a common header or equalizer on each side of the evaporation zone will stabilize the flow through the parallel circuits.
4. Superheater and economizer circuits are more stable than evaporation-zone circuits.
5. If only one equalizer or header is used, it should be placed at the end of the economizer zone rather than at the end of the evaporating zone.
6. The stability of parallel circuits is independent of capacity.
7. The stability of superheater circuits is independent of pressure.

Dean Potter concluded with a statement of the investigations now under way at Purdue which will involve a study of the reaction between steam and different

metal alloys at temperatures between 800 and 1400 F. It is expected to have sufficient data available to present the results of this study at the 1937 Spring Meeting of the A.S.M.E.

In leading the discussion on this topic at Philadelphia, **George A. Orrok,** consulting engineer of New York recalled that as early as 1830 Perkins had attempted to use steam at above the critical pressure in a once-through boiler, using a feed pump that put the measured quantity of water into the boiler in proportion to the number of revolutions of the engine so that the steam demand and boiler feed would be balanced. He reviewed the so-called special types of high-pressure boilers such as the Benson, Loeffler and Sulzer, several of which he had been privileged to observe in operation and one of which he had tested. From these observations it was his opinion that the success of the once-through boiler depends largely upon the control, and that generating steam at critical pressure is not as satisfactory as at sub-critical pressure. If steam is to be produced at or near critical pressure the feedwater should be heated up to that point by the regenerative cycle, and the superheating above 700 deg accomplished in steps.

Subsequent discussion brought out that present German practice seemed to favor more the conventional natural circulation boiler for high-pressure service than the so-called special types, although several of the latter are now being installed in England. However, the La Mont type is popular on the Continent.

Paul Sidler, of Brown, Boveri & Company, told of the Velox boiler installation at Oser, Norway. This consists of two 165,000 lb per hr, oil-fired units operating at 400-lb pressure, 800 F steam temperature which supply a 33,000 kw turbine-generator for standby and peak-load service. The quick starting ability of the Velox steam generator was a factor in its selection for this service. Incidentally, Mr. Sidler pointed out that the design of the Velox unit permits its being completely assembled and tested in the shop before shipment.

Control of Superheat

Perry Cassidy, of Babcock & Wilcox Company, at the Philadelphia session listed the operating factors

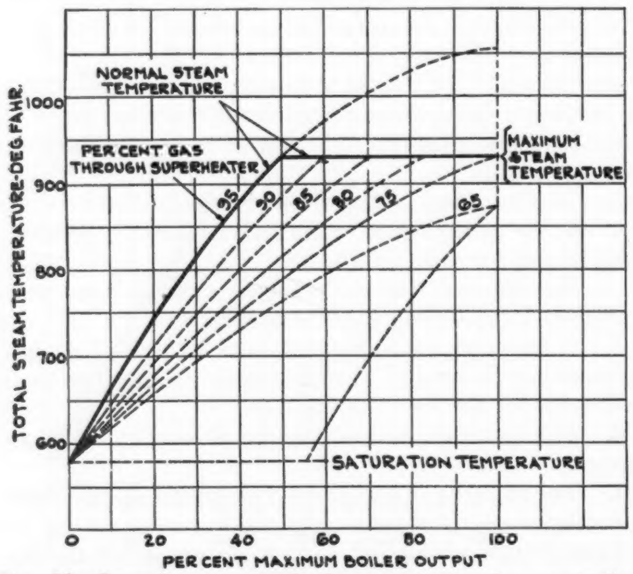


Fig. 12—Superheat control characteristics for controlled gas flow

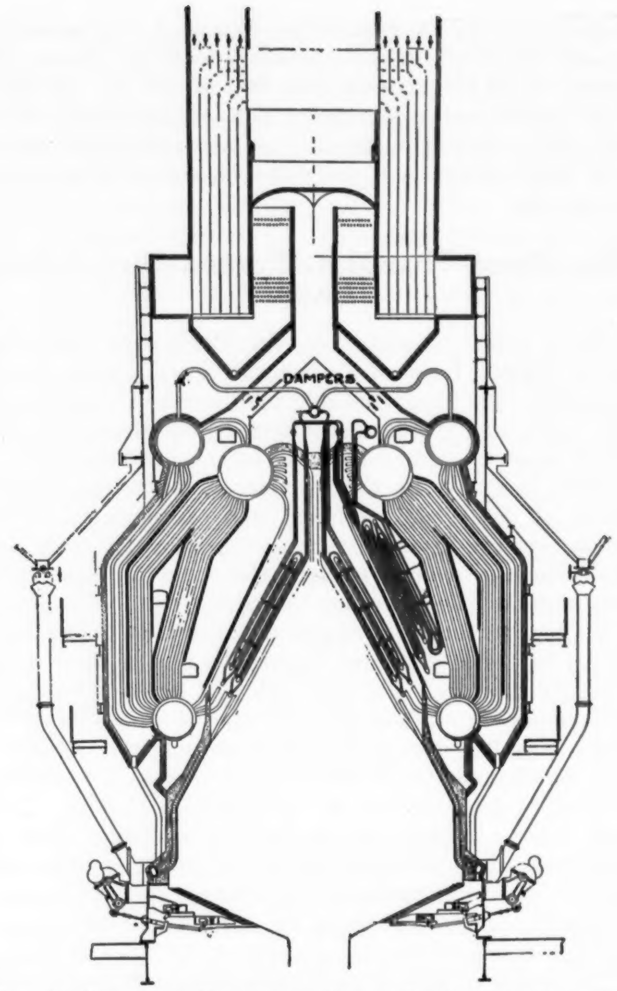


Fig. 13—Compensating type of superheat control as employed at Conners Creek Station, Detroit

that affect superheat as follows:

1. Change in fuel analysis.
2. Variation in percentage of excess air.
3. Variation in feedwater temperature, and in rate of flow.
4. Variation in gas temperature entering the superheater.
5. Variation in quantity of boiler blow-down.

Superheat control will compensate for these various factors, constant steam temperature from maximum boiler output to two-thirds or one-half maximum being representative of economic practice, although a wider range can be obtained if required.

One method of accomplishing superheat control is by means of a convection type of desuperheater arranged in series between two sections of the superheater. This is shown diagrammatically in Fig. 10. Characteristic performance when using such a desuperheater is shown by the curves in Fig. 11.

Mr. Cassidy also showed curves, Fig. 12, giving characteristic performance where the superheat is regulated by controlling the gas flow over two parallel passes interposed between the boiler sections and the air heater. The superheater is located in one of these passes, followed by the economizer; additional economizer surface being located in the other pass. The percentage of gas flowing through each pass is controlled by dampers located between the outlet of the two parallel passes and the entrance to the air heater.

With such an arrangement, any temperature between saturation and maximum may be maintained by adjustment of the dampers within the limits of about 95 per cent gas flow through the superheater pass and the maximum gas flow through the economizer pass, as determined by fan capacity.

This type of control is well suited to superimposed units where it is sometimes necessary to adjust the temperature of the steam entering the high-pressure turbine at reduced outputs, so as to assure steam of safe temperature at the entrance to the low-pressure turbines.

Discussion of this topic was opened at Pittsburgh by a paper by **W. A. Armacost,**[3] of The Supherheater Company, who called attention to the fact that the trend toward higher steam pressures and temperatures in the last few years has made it more necessary for superheater designers to work very closely with the boiler designers in order to produce a simple, efficient coordinated steam generating unit. With the advent of high pressures and steam temperatures of 800 to 1000 F it became necessary to have a positive control over the superheat. Variations in superheat with operating conditions may amount to 50 deg F or more in large superheaters, while with low superheats of around 100 deg F the variation would be about 15 deg F or less.

In high-pressure, high-temperature boiler units, it has been found advantageous to obtain the normal steam temperature at as low an output as possible. By obtaining the full steam temperature at some lower output, such as 50 per cent full load, a much larger superheater is required, but by providing a positive means of control, the steam temperature can be maintained at the desired point at any higher output. Similarly, when burning several fuels, such as oil, pulverized coal, natural gas and blast furnace gas, either separately or in combination in the same furnace, the superheater can be designed to give the full steam temperature with the most unfavorable fuel and controlled so as to maintain that temperature with the other fuels.

The heat absorbed by convection superheaters depends primarily upon:

1. The extent and arrangement of the surface.
2. The temperature of the products of combustion entering the superheater.

[3] Presented in Mr. Armacost's absence by F. I. Epley of The Superheater Company.

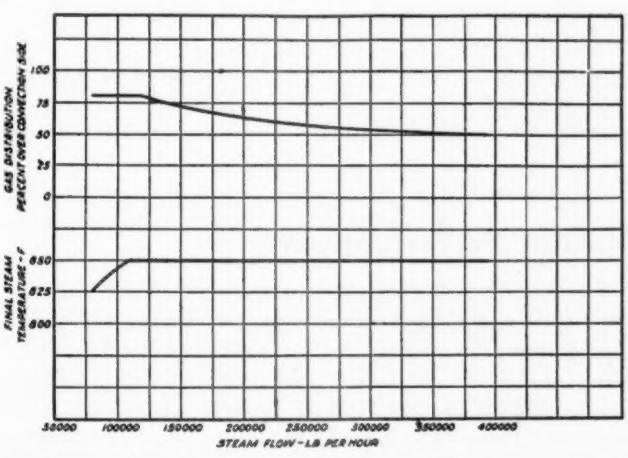


Fig. 14—Predicted curves of superheater performance with compensating arrangement

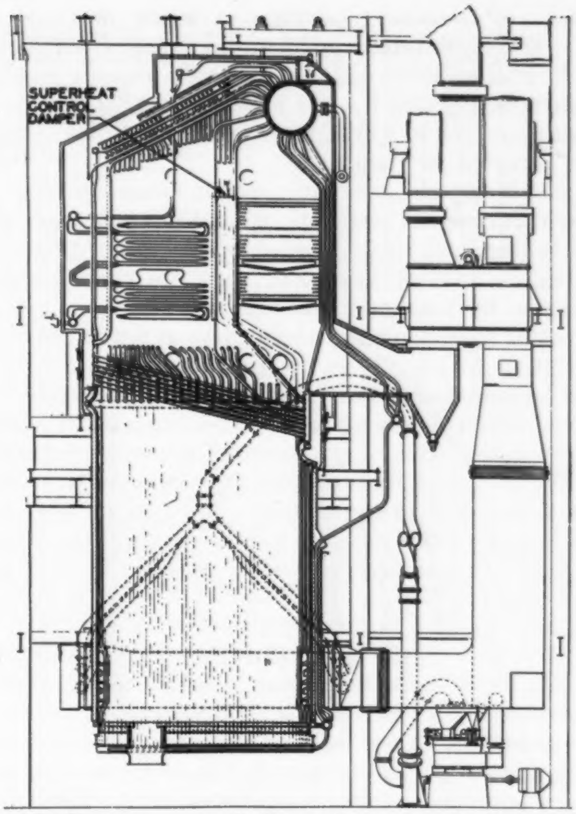


Fig. 15—Damper controlled superheater applied to straight tube cross-drum high-pressure boiler

3. The velocity of the gases through the tube bundle.

Thus, after fixing the extent and arrangement of the surface to meet certain steam conditions with certain gas conditions existing, any change or variation in steam conditions will be caused principally by a change in gas conditions. Because of this relation, the steam temperature will decrease with a decrease in load; also, when a furnace becomes clogged, the steam temperature will increase accordingly.

Mr. Armacost then reviewed the several methods of controlling steam temperature, such as the use of a desuperheater, of either the non-contact surface type or the spray or cartridge type and the control of gas flow over the superheating surface; the last-named method representing the present trend among later installations in this country. Slides were shown of several installations embodying this latter arrangement. Among these, Fig. 13 represents a compensating type as applied to a double-set boiler fired by a double-ended multiple-retort stoker. This design has been successfully applied to five boilers at the Conners Creek Power House of the Detroit Edison Company. The temperature regulation obtained with this design is shown by Fig. 14. Of particular interest is the uniform steam temperature over the wide range in load. Under routine operation the steam temperature can be controlled within 5 deg F, plus or minus. Fig. 15 shows an arrangement of damper controlled superheater as applied to a straight-tube cross-drum boiler. Two 1400-lb, 900-deg boiler units of this design are now building for the Waterside Station of the New York Edison Company. In this design, the superheat may be bypassed entirely by part of the combustion gases.

In discussing this subject further, **Dipl. Ing. E. Lupberger,** of Berlin, stated that in the existing power

stations in Germany operating at steam pressures of 500 to 600 lb, the steam temperatures range from 770 to 810 F, whereas those of 1500 to 2200-lb pressure employ steam at 900 to 958 F; and in one case 1000 F. Temperatures of 784 F, 842 F, 900 F and 1000 F have lately been accepted as standard.

Radiant superheaters are used in Germany only in a few experimental installations, and in these cases the superheaters are placed near water tubes that are exposed to radiant heat, and they are therefore not subject to the most severe conditions.

In order to obtain a superheat curve as flat as possible, in relation to load, it is the practice to place only a small amount of water heating service between the furnace and the superheater. The superheater tubes are therefore placed in the range of flue-gas temperatures of 2000–2100 F, where they are exposed simultaneously to radiation and to conduction. In order to keep the temperature of the tubes as low as possible, the steam velocities at the superheater are kept at 45 to 55 ft per sec for pressures up to 570 lb and at 35 to 45 ft per sec for pressures of 1500 to 2100 lb per sq in. To obtain uniform steam admission into all superheater elements, the saturated steam connections are distributed over the whole length of the drum.

De-superheaters for medium and high pressures are nearly always placed between two superheater sections, thereby obtaining a lower temperature of the tube walls in the second section of the superheater. The de-superheaters are either of the surface type located in the upper drum, or of the injection type. In the latter case, it is often necessary to use an intermediate header of the superheater as a housing for the de-superheater.

Size Versus Unit Cost of Steam Generating Units

In discussing Mr. Powell's paper on "Design Trends for 500- to 600-Lb Steam Plants" at the recent Niagara Falls Meeting of the A.S.M.E., John Van Brunt, Vice President of Combustion Engineering Company, gave some interesting figures showing the influence of size on cost of boiler units.

Assuming the base cost per 1000 lb of steam per hr from a 100,000 lb per hr boiler at 450-lb pressure and 775 F steam temperature to be unity

For a	200,000	lb	per	hr	unit	the	cost	will	be 0.70
" "	300,000	"	"	"	"	"	"	"	" 0.60
" "	400,000	"	"	"	"	"	"	"	" 0.55
" "	500,000	"	"	"	"	"	"	"	" 0.525
" "	750,000	"	"	"	"	"	"	"	" 0.50
" "	1,000,000	"	"	"	"	"	"	"	" 0.485

While these figures are for 450-lb press, the ratios will be about the same for higher pressures.

One of the factors in this relation is the engineering and design costs of modern units. To design and detail a complete steam-generating unit for 100,000 lb per hr capacity, including boiler, furnace, water walls, superheaters, economizers, air heaters, fuel burning equipment, pulverizing mills, boiler casing, forced- and induced-draft fans and ducts will require from 8000 to 10,000 drafting hours, and including supervision and engineering, will cost from $25,000 to $30,000. The cost of design for a 300,000-lb unit will be but little more, and a unit of 1,000,000 lb may take 15,000 hr.

New A.S.T.M. Specifications for Ferrous Metals

At a recent meeting of the A.S.T.M. Committee E-10 on Standards there were approved for publication as tentative a number of new specifications recommended by A.S.T.M. committees functioning in the ferrous metals field. Four of the new specifications were developed and approved by the Committee on Steel. These cover high-strength rivet steel, seamless-steel boiler tubes and superheater tubes for high-pressure service, alloy-steel bolting materials for high-pressure at temperatures up to 1100 F and nuts for bolts for high-pressure and high-temperature service to 1100 F.

The new specifications covering seamless-steel boiler tubes provide for more rigorous and more numerous tests than in the existing A.S.T.M. Standard covering lap-welded and seamless steel and lap-welded iron boiler tubes. The specifications cover boiler tubes and superheater tubes 2 in. in outside diameter or larger and heavier than 0.203 minimum wall thickness.

The new specifications for steel nuts cover five grades of nut material for services varying in degree of severity: Two grades for respective service under the least exacting and most severe conditions, with three classes for use between these two extremes. The chemical requirements provide for carbon steel for the first four grades and the chemistry for the grade for most severe service covers a 4–6 per cent chromium steel with the permissible addition of molybdenum or tungsten. Other types of alloy steel with their appropriate heat treatments approved by the purchaser may be submitted under this class. Three types of tests are provided, namely Brinell hardness, drift and stripping tests.

The new alloy-steel bolting material specifications for high-pressure and high-temperature service to 1100 F cover five classes of materials: A, B, C, D and E, Class E being an austenitic steel. The minimum tensile strength, after final heat treatment, for bolting materials $2^1/_2$ in. in diameter and under, ranges from 95,000 lb per sq in. for Class A to 135,000 lb per sq in. for Class D.

While the composition of the steel is to be agreed upon by the manufacturer and the purchaser, it may be selected from five steels listed in the body of the specifications which provide definite compositions. These steels are of the following types: nickel-chromium-molybdenum, 4–6 per cent chromium, chromium-molybdenum, tungsten-chromium-vanadium and tungsten-chromium. The committee has included in an appendix data relative to the chemical and physical properties of several alloy-steel bolting materials in addition to those given in the body of the specifications.

Station Performances

The record performance established by Port Washington Station during April was passed during the month of July when the average station heat rate was a kilowatt-hour on 10,800 Btu, net. Also, the rebuilt Conners Creek Station of the Detroit Edison Company, had a heat rate, from March to June, inclusive, of a kilowatt-hour on 12,450 Btu, net. This was exclusive of the old section of the station.

High Spots of German Power Plant Practice*

By DR. ING. OTTO SCHÖNE

SEVERAL plants are in operation or in the course of erection in Germany for operating pressures in excess of 1800 lb per sq in. and total steam temperatures in excess of 850 F, exclusive of those containing the so-called special types of boiler such as the Benson, Loeffler, etc. The German B & W Company will soon complete a plant designed to operate at 2100 lb and 932 F for a maximum capacity of 170,000 lb of steam per hour. Another plant furnished by the Kohlenscheidungs Gesellschaft is designed for 2000-lb pressure, 932 F total steam temperature and a capacity of 264,000 lb per hr.

The extent of the trend to high pressure is best illustrated by the fact that up to the first of August of this year, there were fifty boilers in operation or in the course of erection for pressures above 1500 lb and over 100 for pressures over 750 lb. The majority of these boilers are in industrial plants. The utilities have comparatively few high-pressure boilers and these are mostly used for superposition in existing stations.

Although the majority of boilers now in service in Germany are of small capacity and low pressure there is a marked trend in the later installations toward high steam pressures and high temperatures and relatively large capacities although not large as compared with many units now building in the United States. Aside from the so-called special types of forced-circulation boilers numerous units are under construction for pressures in excess of 1500-lb pressure. Most of these are for industrial power plants.

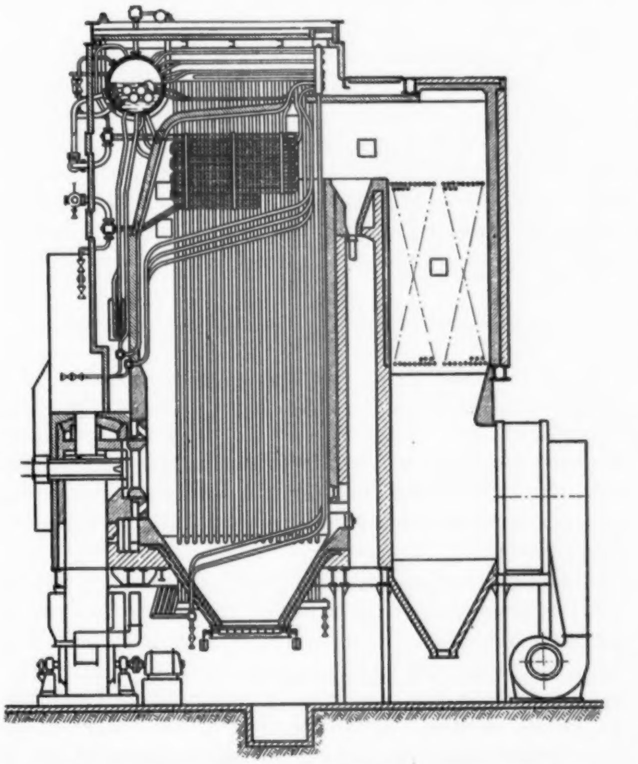


Fig. 1—Single-drum boiler for 1260-lb pressure, 840 F steam temperature and 143,000 lb of steam per hour, equipped with the Kramer system of firing

Contrasting with this trend is the fact that 71 per cent of all boilers in Germany have less than 1000 sq ft of heating surface and 60 per cent are for pressures less than 150 lb. By number, 54 per cent of all boilers are still of the Lancashire type. Above 300-lb pressure there are 1.3 per cent by number and 7.0 per cent by heating surface. More than 22 per cent of all the boilers are 36 years old and since these will have to be replaced soon, there is likely to be a marked shift in the given figures in the direction of higher pressure and higher unit capacity in a comparatively short time.

The increase in unit capacities and in the steaming rates has similarly progressed. In 1920 the average boiler had a steaming rate of 5 lb per sq ft per hr, whereas today it is 50, or ten times as much.

Special Types of Boilers

Under this classification are understood the Benson, Schmidt, Loeffler, Sulzer, La Mont and Velox types. Only the first four are high-pressure boilers, although the Benson boiler is now built for lower pressures as well. The Benson, La Mont, Loeffler and the Sulzer have forced circulation, which makes the disposition of heating surface less of a problem. Of these types, the La Mont boiler has enjoyed the greatest popularity, not only for new installations but also as a means of increasing the capacity of existing boilers. There is only one Sulzer boiler in Germany operating at 1500 lb. The Loeffler boilers installed at the I. G. Dye Trust plant at Hoechst on the Main, have received wide publicity. One central station has six Schmidt boilers for 1500-lb pressure and 860 F total steam temperature. Despite the increasing number of Velox installations in Europe, none are to be found in Germany. The Velox is a steam generating machine rather than a boiler. Its features

* Abstract of a talk by the author at the Niagara Falls Meeting of the A.S.M.E. on Sept. 18, 1936. Dr. Schöne also was the author of a more extended paper on this subject which appears in the World Power Conference special issue of *Zeitschrift des Vereines Deutscher Ingenieure* of August 22.

of high-pressure combustion and extremely high heat transfer are well known and need not be discussed here.

Developments in Boiler Design

The transition to high-pressure steam generation was made possible by:

1. New suitable heat-resisting materials,
2. Better feedwater,
3. Improved circulation and steam release through better boiler design.

The alloys now available in Germany meet all present requirements as to pressure and temperature. One German plant will use 987 F steam temperature. The steam at this temperature is first cooled in a steam reheater to 842 F before it enters the turbine.

Regarding feedwater, the least difficulties are experienced with condensate for makeup. The steam converter is the result of the desire to eliminate the large and expensive feedwater treatment plants, especially where the makeup percentage is large. The steam converter is a heat exchanger in which low-pressure steam for the low-pressure stages or processes is generated with the steam from the high-pressure stage. With good circulation the oxygen content may be as high as 0.1 mg per liter without danger from corrosion. With condensate, the sodium hydroxide concentration need be only between 15–30 mg per liter. It must be higher with treated water for makeup.

Oil in boiler water is less troublesome in high-pressure boilers than in low-pressure boilers, since at the high temperatures the oil evaporates or is removed with the blowdown.

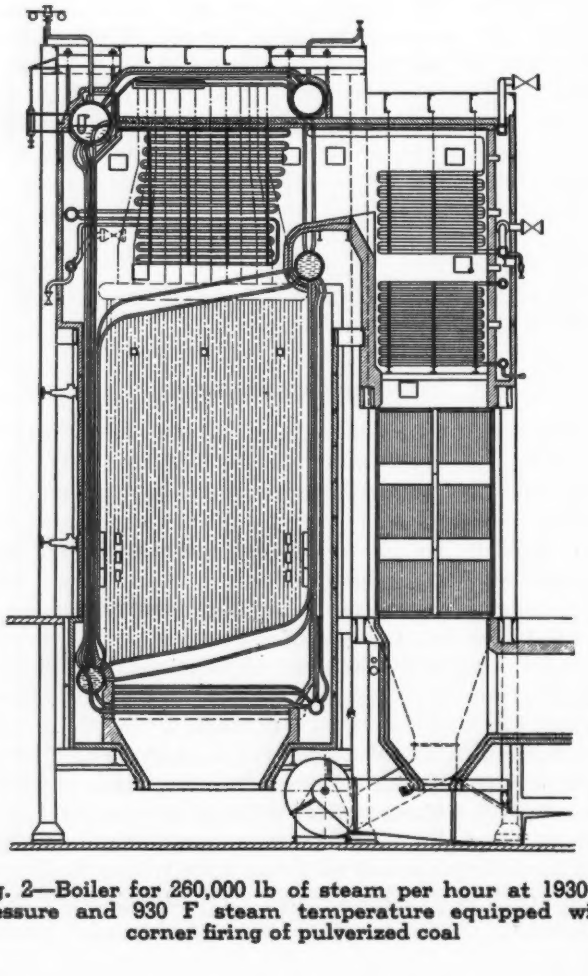


Fig. 2—Boiler for 260,000 lb of steam per hour at 1930 lb pressure and 930 F steam temperature equipped with corner firing of pulverized coal

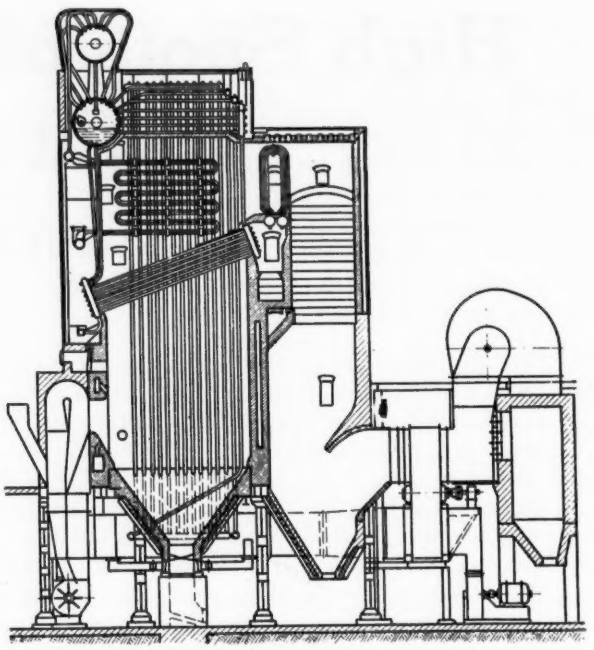


Fig. 3—Sectional header type of boiler for 1775 lb per sq in., 900 F steam temperature and 88,000 lb per hr capacity. It is equipped with a Ljungstrom air heater and the Kramer system of mill firing

With conditioned water, the soluble salt concentration is likely to be high, leading to carry-over and salt deposition in the turbine. If the salts are readily soluble, washing with wet steam will remove them, otherwise the turbine must be boiled out. With special treatment, the soluble concentration may be reduced sufficiently so as not to cause carry-over, but the bulkiness of the treatment plant and high cost of operation are against it.

Only Two- and Three-Drum Designs Prevail

High-pressure steam has considerably influenced the design of the boilers. The high cost of the drums brought about a reduction in the number of drums so that today only the two-drum and single-drum designs prevail. The former lends itself to a simple disposition of heating surface for positive circulation, as experience has proved.

Other design features brought about by high pressure are the great reduction in boiler heating surface proper, and the increase of economizer surface in order to preheat the feedwater to the high saturation temperatures. In most cases it is a steaming economizer which often generates as much as 20 per cent of the steam output. The downcomers are placed out of the path of the flue gases.

In line with the trend to higher capacities, the convection heating surfaces are replaced by radiant heating surfaces which permit of higher furnace heat release as well as higher temperature. The radiant superheater, however, has not found favor and has been employed in only a few cases. The superheat is in some cases effectively regulated by means of a bypass cooler placed inside the boiler drum.

The higher steam outputs per boiler are the result of improvements in firing equipment. Outstanding is the

progress in zoned chain-grate stokers and in pulverized coal firing. Of special interest is the rapid introduction of the Kramer type pulverizer built integral with the boiler. This is considered the most successful type of firing method in Germany today. It is of the impact type, the fines and particles of burnable size being swept into the furnace by the combustion air stream. Oversize particles drop back into the mill to undergo further disintegration. This method, however, is not suited for coals with lower than 15 to 20 per cent volatile. Coals high in ash content or otherwise difficult to burn are successfully handled. Only the unit mill is now considered for pulverized coal installations and tangential firing is mostly used. Underfeed stokers are very rarely installed.

For reasons of national economy it becomes necessary often to burn coals of exceedingly poor quality such as for instance those with 3000 Btu heat value and 40 to 45 per cent ash. In some cases boilers are equipped with two firing methods to enable them to burn cheaper grades of coal simultaneously with the better grades.

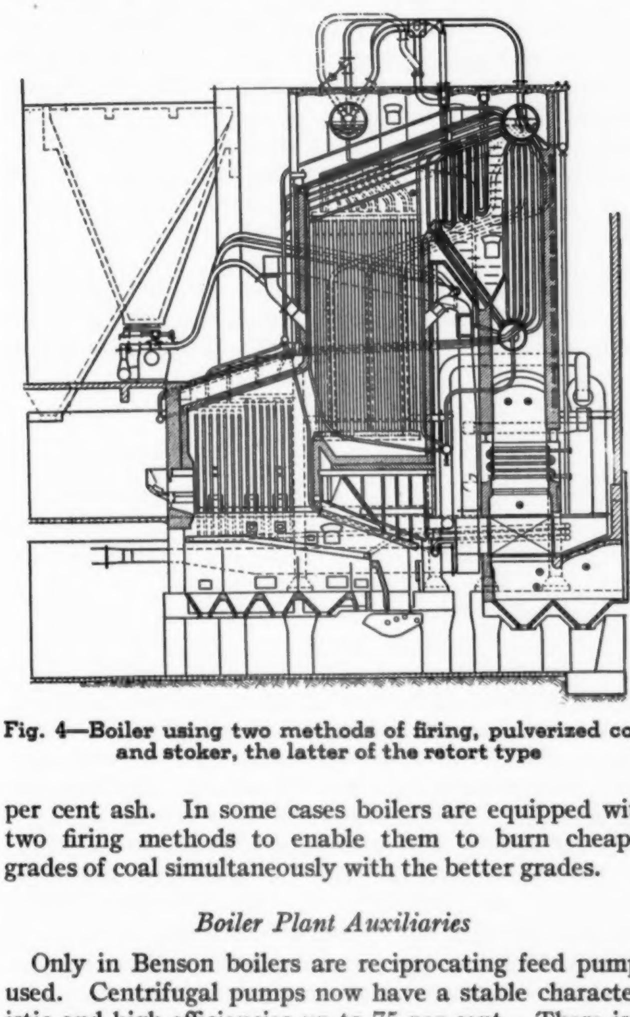


Fig. 4—Boiler using two methods of firing, pulverized coal and stoker, the latter of the retort type

Boiler Plant Auxiliaries

Only in Benson boilers are reciprocating feed pumps used. Centrifugal pumps now have a stable characteristic and high efficiencies up to 75 per cent. There is a tendency to increase further their speeds up to 10,000 rpm. At present the speeds are from 3800 to 5500 rpm.

Steam engines for high pressures are rarely considered and then only for small outputs, although so far none smaller than 1200 hp have been built. The turbines have reverted to the single casing design where the capacity permits. The single casing turbine is preferred up to capacities of 30,000 or 40,000 kw, according to the vacuum. If higher efficiencies are desired or for high designed pressure drops the two-casing turbine is used. The trend to higher speeds is quite evident. Very few turbines are still being built with speeds of 1500 rpm. Turbines up to 60,000 kw are operated at 3000 rpm. To utilize further the advantage of high-pressure steam, still higher speeds are now being employed, this being made possible by the new high efficiency reduction gearing. Thus, on a steamer, the high-pressure stage turbine is operated at 18,000 rpm, the intermediate stage at 15,700 rpm, and the low-pressure stage at 6500 rpm, for a total capacity of 6000 hp for the three turbines, all three transmitting the power to the shaft through reduction gears.

The total power produced by high-pressure steam over 1500 lb, in high-pressure stages aggregates approximately 285,000 kw. Most high-pressure turbines in Germany today serve as superposed units on existing lower pressure installations. Radial turbines are of two types, Ljungstrom and Siemens Schuckert. The former is mostly used for condensing or back-pressure service. The Siemens Schuckert turbine is primarily a back-pressure machine although in some cases it is used as a condensating turbine, and then only for peak loads. The largest size Ljungstrom turbine has 50,000 kw capacity at 1500 rpm. Initially it will operate with steam at 200-lb gage, but is designed for 450-lb gage to take care of future increase in load.

An interesting design is that of a 3500-kw Siemens Schuckert turbine with an overhanging wheel so as to eliminate the high-pressure packing. This design is contemplated also for higher capacities.

Standard Markings for Valves and Fittings

A new edition of the "Standard Practice" covering the standard marking system for valves, fittings, flanges and unions, has just been issued by the Manufacturers Standardization Society of the Valve and Fittings Industry, 420 Lexington Ave., New York. The method of applying the general rules for marking as set forth in the previous rules is more specifically visualized in this new edition, by the inclusion of a number of tables definitely outlining the standard method of applying uniform markings to a wide variety of products.

Dr. Samuel M. Kintner, Vice-President in Charge of Engineering of the Westinghouse Electric & Manufacturing Company died in Pittsburgh on September 28 at the age of sixty-four. He was a graduate of Purdue University and after several years in teaching, joined the research department of the Westinghouse Company in 1903.

H. W. Fuller, Vice-President in Charge of Engineering and Construction of the Byllesby Engineering & Management Corporation, Chicago, died suddenly at Basswood Lake, Minn. on August 28th. Subsequent to his graduation from Rutgers in 1891 he was associated with the General Electric Company, the Washington Railway & Electric Company and the Potomac Electric Power Company, joining the Byllesby organization in 1911.

MODIFICATIONS of the HOT PROCESS when Conditioning Makeup for High-Pressure Boilers

By C. JOOS

Cochrane Corporation, Phila., Pa.

The chemical reagents most commonly used in the hot-process softener for conditioning boiler feedwater are lime and soda ash, the reason being that these chemicals are both cheap and effective. The precipitation type of softener equipment is so designed, however, that supplementary chemicals can be used or other chemicals can be substituted, and the purpose of this article is to explain the variations from, or the modifications of, the conventional lime and soda ash treatment that are most frequently used, particularly to meet the requirements imposed by high steam pressure and by high rates of driving boilers.

LIME and soda with supplementary treatment by phosphate are commonly used in preparing water for high-pressure boilers, particularly in industrial plants where the makeup is relatively large. With turbid or high carbonate waters, the precipitation of the hardness by lime and soda ash is sufficient to induce coagulation and precipitation of foreign material, thereby simplifying the problem of clarification. The precipitation of the carbonates by lime reduces the dissolved constituents so that the total solids are only a fraction of those present in the original raw water and resulting substances are non-scale forming. Briefly, lime precipitates the temporary hardness, or carbonates, while the soda ash precipitates the permanent hardness, such as calcium sulphate. An excess of soda ash is provided in order to reduce the hardness and to build up the boiler water alkalinity for protection against scale formation and corrosion.

While the chemical reactions involved are familiar to most persons concerned with feedwater treatment they will be set down for clarity in explaining advantages of this treatment:

(1) $Ca(HCO_3)_2 + Ca(OH)_2 \ldots\ldots\ldots 2CaCO_3 + 2H_2O$
(2) $Mg(HCO_3)_2 + 2Ca(OH)_2 \ldots\ldots Mg(OH)_2 + 2CaCO_3 + 2H_2O$
(3) $CaSO_4 + Na_2CO_3 \ldots\ldots\ldots\ldots\ldots CaCO_3 + Na_2SO_4$

Equations (1) and (2) illustrate the precipitation of carbonates by lime, which occurs without the formation of a byproduct and leaves only a small amount of carbonates in solution, the amount depending upon the temperature at which the reaction takes place and upon the excess of reagents. In equation (3) the calcium sulphate is precipitated as calcium carbonate, leaving the soluble byproduct sodium sulphate. It is evident that in the treatment of a water of high temporary hardness the solids are materially reduced and the alkalinity or excess soda ash is under the direct control of the operator. The residual hardness is controllable within limits by varying the excess of reagents. It can be reduced to what is commercially termed "zero hardness" if there is sufficient soda ash. While the hardness can be reduced to extremely low limits, it is not generally advisable to do so as the high excess soda ash needed would result in increased cost and in higher boiler water alkalinity, which might induce foaming and priming tendencies and possibly create difficulties in the maintenance of the ratio of sulphate to carbonate recommended by the A.S.M.E. Code to avoid embrittlement of the boiler metal.

Table I gives the results obtained with lime and soda ash treatment in a hot-process softener in a 600-lb boiler plant, using a moderate excess of sodium carbonate.

TABLE I

Substance	Raw water	Treated water
Calcium carbonate	12.08	0.58
Calcium sulphate	2.62	
Magnesium carbonate	4.90	
Magnesium chloride		
Magnesium hydrate		0.06
Silica	0.82	0.29
Iron oxide	0.06	0.06
Sodium carbonate		1.81
Sodium sulphate	2.33	4.26
Sodium chloride	2.68	2.10
Sodium hydrate		0.06
Volatile and organic	1.69	0.93
Total solids	27.18	10.15

The water is predominately carbonate and the solids are materially reduced by the lime and soda treatment. An advantage of the lime and soda treatment which is often overlooked is its ability to coagulate the precipitate silica and organic materials. The reduction in silica and organic matter is approximately 60 per cent, which is appreciable and important in the operation of high-pressure boilers, where these two materials should be reduced to very low values in order to avoid siliceous scale and foaming and priming tendencies.

Table II illustrates the reduction in silica brought about by hot-process softeners in a number of plants where the raw water contained in excess of 15 ppm.

The use of lime and soda only is not recommended for boiler pressures in excess of 250 lb per sq in., where supplementary treatment with phosphate is desirable. The tendency for silica scale to form increases at high pressures and, to offset this tendency, phosphate is introduced directly into the boilers to provide an excess of the phosphate radical, which is stable and forms a precipitate of calcium phosphate, preventing the silica from combining with calcium and forming calcium silicate scale. The supplementary treatment with phosphate also makes possible the maintenance of low boiler water alkalinity

TABLE II

Sample No.	Silica, ppm Raw	Silica, ppm Treated	Silica, ppm % Reduction	Organic Matter, ppm Raw	Organic Matter, ppm Treated	Organic Matter, ppm % Reduction
1	50.2	28.0	53	102	11	89
2	54.0	18.0	67	99	52	48
3	38.8	19.2	51	95	27	72
4	35.2	22.4	36	91	43	53
5	28.4	12.2	57	79	51	35
6	27.0	12.0	55	69	42	39
7	26.4	6.0	77	62	2	97
8	26.0	11.6	55	54	33	39
9	24.6	8.2	67	54	1	98
10	24.0	11.2	53	52	24	54
11	23.0	13.8	40	52	7	87
12	22.4	9.7	57	49	9	82
13	22.0	15.2	31	41	15	63
14	21.6	6.4	70	40	5	88
15	20.8	6.8	67	36	21	42
16	20.6	7.6	63	31	21	32
17	20.0	8.0	60	26	13	50
18	10.4	6.4	67	26	3	88
19	19.2	9.6	50	19	6	69
20	19.0	10.0	47	19	9	53

which is conducive to smoother boiling and makes easier the maintenance of sulphate ratios in accordance with the A.S.M.E. Code.

By feeding the phosphate to the boilers, any remanent hardness from the hot process softener is precipitated as calcium phosphate, usually as a very finely divided and non-adherent sludge. The supplementary phosphate is usually in the form of mono-sodium, or meta-phosphate, which is acid and has the property of reducing the alkalinity. The chemical reactions of the phosphates with the residual hardness and with the excess soda ash are illustrated below in equations (4) and (5), in which the reduction in alkalinity occurs by the discharge of CO_2 in much the same fashion as if sulphuric acid were added to a carbonate.

(4) $2CaCO_3 + 2NaH_2PO_4 \ldots Ca_3(PO_4)_2 + Na_2CO_3 + 2H_2O + 2CO_2$
(5) $Na_2CO_3 + NaH_2PO_4 \ldots Na_3PO_4 + H_2O + CO_2$

Caustic Soda Treatment

Caustic soda may be substituted for lime and soda ash if the carbonate and permanent hardness are present in the right proportions. The possibility of using caustic soda instead of lime and soda ash depends upon the production of soda ash by combination of the caustic soda with the bicarbonate radical. Precipitation of hardness by caustic soda under proper conditions does not differ from precipitation by lime and soda ash, as the latter, mixed in proper proportions, will form caustic soda. The reaction of caustic soda with the production of sodium carbonate is shown in the equations (6) and (7).

(6) $Ca(HCO_3)_2 + 2NaOH \ldots\ldots CaCO_3 + Na_2CO_3 + 2H_2O$
(7) $Mg(HCO_3)_2 + 2NaOH \ldots\ldots Mg(OH)_2 + 2Na_2CO_3 + 2H_2O$
(8) $MgSO_4 + 2NaOH \ldots\ldots Mg(OH)_2 + Na_2SO_4$
(9) $CaSO_4 + Na_2CO_3 \ldots\ldots CaCO_3 + Na_2SO_4$

The sodium carbonate so produced is consumed partially by the permanent or calcium sulphate hardness, with the precipitation of calcium carbonate and the formation of sodium sulphate in accordance with equation (9).

From these equations it will be evident that caustic soda should not be utilized alone for the treatment of high carbonate waters, such as that shown in Table I, since it would produce such a high excess of sodium carbonate which would not be consumed in the precipitation of calcium sulphate and there would be a high excess of sodium carbonate in the treated water, resulting in high boiler water alkalinity. The cost of treatment would, in addition, be excessive.

The caustic soda treatment can be applied only to waters in which the permanent hardness in the form of calcium sulphate is sufficient to consume most of the soda ash resulting from the reaction with the carbonates. Such a balance is not generally found in the natural water supplied, and, moreover, the relation of carbonates to permanent hardness in surface streams varies from time to time, so that treatment with lime and soda is preferable. Caustic soda can, however, be used in conjunction with lime where the carbonates predominate or with soda ash where the permanent hardness is high, but in either case the result is the same as from treatment with lime and soda ash, with the disadvantage of using three chemicals instead of two.

Lime-Gypsum Treatment with Supplementary Phosphate

In certain districts the water from wells contains sodium carbonate or soda ash in too great amount for use as boiler feed without reduction. Such waters are found in central Illinois, in the vicinity of Houston, Texas, and at Long Beach, Cal. They are generally high in silica and low in sulphates and can be treated efficiently by lime for the precipitation of calcium and magnesium bicarbonates, and by gypsum and calcium sulphate for the precipitation of sodium carbonate, only sufficient gypsum being added to precipitate the sodium carbonate partially, leaving the desired excess of sodium carbonate for the prevention of scale and corrosion. The reaction of the gypsum with the natural sodium carbonate is given in equation (9).

The precipitation of calcium and of magnesium and sodium carbonates is generally sufficient to precipitate the bulk of the silica, although not sufficient for the prevention of siliceous scales, for which reason supplementary phosphate treatment is advocated, irrespective of the boiler pressure.

Sulphuric Acid and Lime with Supplementary Phosphate Treatment

For the waters high in natural sodium carbonate, sulphuric acid is substituted for gypsum in order to take advantage of the lower cost of acid as compared with gypsum. Waters high in sodium carbonate are treated separately with sulphuric acid to neutralize the carbonates partially and then treated with lime in a hot process softener to precipitate the unneutralized carbonates of calcium and magnesium. The sulphuric acid simply converts the sodium carbonate to sodium sulphate, with the production of CO_2 which is removed over an aerating tower or by bubbling air through the water in a separate tank. Supplementary phosphate is added in the boiler to counteract silica and to permit the maintenance of low boiler water alkalinity.

Softening with Phosphates

Tri-sodium, or di-sodium, phosphate has been used as a reagent in the hot-process water softener for a number of years, but generally in conjunction with soda ash and in an amount insufficient to precipitate all of the calcium and to provide an excess of phosphate radical in the softened water. Recently this method of treatment has been perfected to give a character of effluent unequalled by using other reagents.[1]

[1] See "Primary Treatment of Feedwater by Phosphate," by C. E. Joos, *Power Plant Engineering*, April 1936.

This treatment is applicable only to very soft water of the order of hardness not exceeding 3 gr per gal. It is particularly well adapted to turbid waters low in hardness, where coagulation and softening can be brought about in a single apparatus. The phosphate precipitates the calcium so completely that so-called "zero hardness" is obtained. In order to bring about chemical reactions most efficiently, it is necessary to feed enough phosphate to provide an excess of approximately 5 ppm, in terms of tri-sodium phosphate and to maintain a pH value in excess of 8.5. With raw water supplies, the tri-sodium phosphate is used in conjunction with caustic soda, the latter to maintain the pH values required for the completion of the chemical reactions. The reactions with these reagents are:

(10) $3CaCO_3 + 2Na_3PO_4 \ldots\ldots Ca_3(PO_4)_2 + 3Na_2CO_3$
(11) $2CaSO_4 + 2Na_3PO_4 \ldots\ldots Ca(PO_4)_2 + 3Na_2SO_4$
(12) $MgCO_3 + 2NaOH \ldots\ldots Mg(OH)_2 + Na_2CO_3$
(13) $MgSO_2 + 2NaOH \ldots\ldots Mg(OH)_2 + 2NaCl$

The effectiveness of this treatment with natural water low in hardness is illustrated by Table III.

TABLE III

	Parts per Million	
	Raw	Treated
Calcium Carbonate	..	0.5
Calcium sulphate	36.7	..
Magnesium carbonate	7.2	0.4
Sodium carbonate	..	42.8
Sodium sulphate	7.1	73.2
Sodium chloride	8.2	8.2
Sodium phosphate	..	15.8
Magnesium sulphate	19.9	

These reagents used in the hot-process softener give an effluent high in pH value and low in oxygen and hardness. They open up a new field for the hot-process softener in the case of comparatively soft water supplied, where with lime and soda as reagents, reduction in hardness may amount to only one-half of the initial hardness. It also provides a simplified means for proportioning phosphate to the water to be treated, eliminating the high-pressure phosphate-feeding equipment customarily used for supplementary treatment with phosphate. The elimination of the precipitation of remanent hardness is an added advantage as it brings about better boiler conditions and smoother steaming.

Two-Stage Softening

For the application of phosphate to softening high carbonate waters, the two-stage method of softening has been developed, combining the use of the cheap chemicals, lime and soda ash, with the economical use of phosphate to precipitate the remanent hardness externally to the boiler. There are now in satisfactory operation a number of two-stage softeners in which the hard water is first treated with lime and soda ash either cold or hot, after which the effluent is delivered to a hot-process softener where phosphate, generally di-sodium phosphate, is added. The remanent hardness, amounting to 15 to 25 ppm, is precipitated in the sedimentation tank, resulting in a water of "zero hardness."

The hot-process water softener is not limited to lime and soda as reagents and the designation "hot lime soda softener" is, therefore, not well chosen. The apparatus might better be called the precipitation type of softener. It can be arranged to feed whatever chemicals may be selected on the basis of raw water conditions. With the proper chemical reagents, the hot-process softener can deliver an effluent that will be satisfactory for even the highest pressure boilers.

Circulation in Water-Tube Boilers

Improper circulation of water in the upper generating tubes of many straight-tube, header-type boilers has long been recognized and has been corrected in some later designs, but in numerous instances it has resulted in excessive boiler maintenance by causing tubes to leak or rupture. Confronted with such conditions in several of its boilers The Northern States Power Company undertook an extensive investigation of the causes in an effort to arrive at a suitable remedy. The results of this investigation are recorded in a very excellent paper by R. M. Hanson of that company which was recently awarded the James H. McGraw first prize in the contest sponsored by the Edison Electric Institute. The paper appears in full in the September issue of the "Edison Electric Institute Bulletin" and the following digest covers some high spots.

ATTENTION of the engineers of the Northern States Power Company was directed to this condition of faulty circulation in 1932 when an upper generating tube of a cross-drum boiler ruptured with explosive violence. The boiler was one of three which had been in continuous service for a little over a year. The rupture produced an opening approximately 35 deg from the top of the tube, starting at a point 21 in. from the uptake header and extending 15 in. toward the downtake header. The metal near the edges of the opening had a thickness from 10 to 20 per cent of the original tube wall. Investigation of this and other top tubes in all three boilers indicated that severe corrosion was taking place over a length of from three to six feet at the high ends of the tubes. The location of this corrosion is indicated in Fig. 1. Examination of the interior of the affected tubes revealed the presence of magnetic iron oxide and this was accepted as direct evidence that the tubes had been overheated. Further examination of all three boilers showed that 140 tubes required replacement because corrosion had reduced the original thickness by at least 35 per cent.

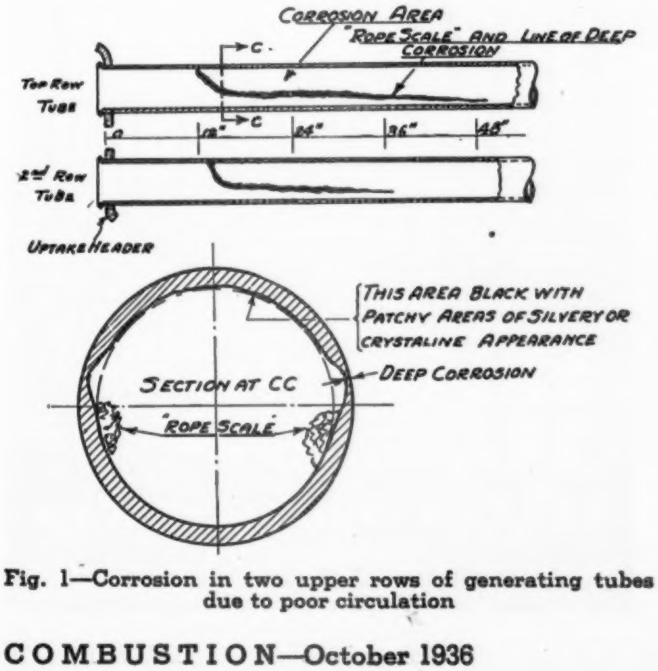


Fig. 1—Corrosion in two upper rows of generating tubes due to poor circulation

In the investigation that followed thermocouples to measure the temperature and spinners to determine the circulation were installed in the tubes. The latter were arranged with cams making electrical contact so as to record the flow within the tubes. The resulting data confirmed the following:

1. The flow in the uppermost generating tubes was found to be coming from the uptake header when the steam flow rating on the entire boiler was below 25 per cent of maximum.
2. The temperature of the upper side of the high end of the uppermost tube was found to increase with the steam flow rating on the boiler, while the temperature of the lower side, just opposite the temperature measuring point in the high side, was found to remain reasonably close to that corresponding to boiler pressure. This indicated that a small stream of water was flowing through what was otherwise a steam space in the tube.
3. When the steam flow rating on the boiler was less than 25 per cent of the maximum the total inflow into the upper bank from the downtake header was a negligible quantity; that is, more water was coming into the upper tube bank from the uptake header than from the downtake header.
4. The total flow of water into the entire header section was greatest when the boiler was operated at about 50 per cent of its maximum steaming rate. Above this rating the flow in the header decreased, and this would indicate that the friction in the circulating tubes was of sufficient magnitude to reduce the rate of circulation even though the boiler output was considerably increased.

Several means were tried in an effort to secure satisfactory tube temperatures in the three boilers. The first method was an attempt to adjust the flow in the entire header section by placing restrictions at various points in the downtake header, it being thought that the pressure at the low ends of the upper tubes might be increased sufficiently to effect adequate circulation. However, the possibility of causing harmful restriction of the flow to the lower tube bank caused this method to be discontinued since it was found that the small changes in area had a negligible effect on the temperatures of the overheated tubes.

The next step was to place restricted orifice plugs in the low ends of the tubes, the theory being that the flow of water from the uptake header into the high end of

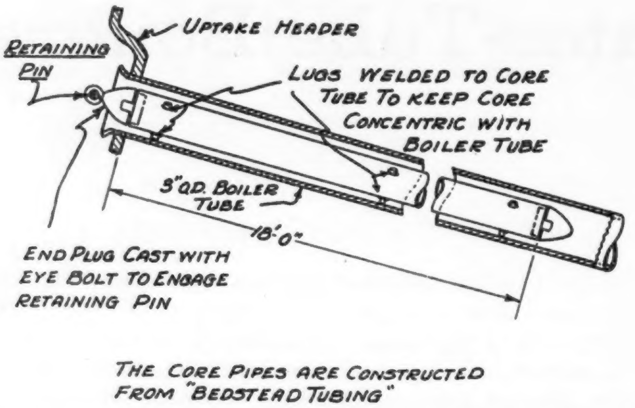


Fig. 2—Core plugs in upper generating tubes to prevent loss of tube metal due to poor circulation

the overheated tubes had sufficient velocity to intrap steam just inside the tube outlet. This pocket, or bubble of steam, grew to considerable length before it was partially discharged into the header, and therefore the tube became overheated at the point where this steam pocket formed. The function of the orifice plug, therefore, was to reduce the velocity of the water flowing into the high end of the tube by limiting the outflow at the low end. This reduction of the velocity down the tube would then, it was thought, allow the steam formed to discharge normally. However, when the orifice plugs were tried the results did not appear to conform to this theory. The plugs that were most effective in keeping the tube temperature normal had very small openings, but solid plugs which had no orifices at all were still more effective. But even with these solid plugs installed, the inflow at the high end of some of the overheated tubes when operating at high steaming rates was apparently scarcely equal to the steaming rate of the tubes; for in one instance a solidly plugged tube suddenly developed an extremely high temperature when the boiler was operating at nearly maximum rating.

The theory, now believed to be correct, regarding the function of the orifice plug, is that it merely limits the outflow of water from the tube until the inflow minus the outflow is greater than the amount of steam generated in the tube, thus allowing the tube to fill with water. Obviously, if the steaming rate of a tube, which has an orifice or solid plug in its low end, is made to exceed the inflow of water at the high end, the plug in the low end becomes dangerous, inasmuch as it may allow the tube to become completely dry.

Another questionable feature of restricting plugs is the tendency of tubes, in which they are installed, to fill up with the solids that normally would pass into the mud drum of the boiler. Because of this and the other objectional features mentioned, restricting plugs were discarded.

The next and final effort to provide suitable cooling for overheated tubes proved successful. This consisted of placing tubular cores within the tubes, one core being required for each tube that was subject to overheating, see Fig. 2. Since these cores have been installed in the three boilers, there have been no tube replacements and no overheating has been noted. The action of the core in cooling the tube appears to result from two sources. First, it provides an annular steam and water space of relatively small cross-sectional area, thus increasing the surface velocities on the inner side of the tube and thereby materially increases the heat transfer rate. The other action is that of decreasing the volume of water in the tube, outside the core, to a point where the volume of steam generated can render the resultant mixture sufficiently light to completely fill the tube and thus provide circulation in the normal direction despite adverse pressure conditions at its ends.

The selection of the proper lengths and diameters of the cores required considerable experimentation. The final installations consisted of two diameters of cores, both 18 ft long. In the two upper rows the cores were $2^1/_4$ in. outside diameter and those in the next four rows were 1.9 in. outside diameter, the tubes themselves being 3 in. with a corresponding inside diameter of approximately 2.6 in.

It is understood, however, that this procedure is advocated only in the event that inadequate circulation is encountered. The proper basis of design in regard to circulation would seem to be the establishment of a definite relationship between the boiler pressure, the rate of steam output per unit of heating surface and those physical dimensions of the boiler which are responsible for the production or limitation of circulating head.

Boilers of the straight-tube type are now being built with greatly increased distances between the drum and the top generating tubes. This fact alone should assist materially in eliminating the difficulty that was inherent in boilers of this type built a few years ago.

MARYLAND COALS—Their Classification and Analyses

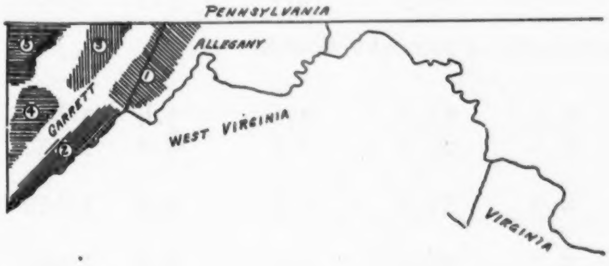
By P. B. PLACE

Combustion Engineering Company, Inc.

Previous articles of this series have dealt with Ohio, Kentucky, Virginia, Illinois, Indiana, Pennsylvania and Tennessee bituminous coals. In each case, as in the present article, the individual seams are traced through various counties, the coals are identified by county and trade names and their characteristics and analyses are given. Knowing the source of a Tennessee coal, its moisture and ash content, a complete analysis may be set up from the values given in the tables which will be sufficiently accurate for most power plant purposes.

MARYLAND'S coal deposits are confined to two counties, Allegany and Garrett, in the western part of the state. These deposits are a part of the eastern boundary of the Appalachian Region and extend northward into Somerset county in Pennsylvania and southward into Preston, Tucker, Grant and Mineral counties in West Virginia. The coal-bearing area has five mining districts as shown on the map, namely, the Georges Creek, Upper Potomac, Castleman, Upper Youghiogheny and Lower Youghiogheny. The bulk of the production comes from the Georges Creek district in Allegany county.

Production in Maryland constitutes only about a half of one per cent of the total bituminous production in the United States and with approaching depletion of the famous Georges Creek seam, the annual output is decreasing. Table I gives the yearly output and relative production in the two counties during recent years.



Although a large number of coal beds have been identified in the coal bearing rocks of Maryland, the coal for which Maryland is famous is from the Pittsburgh seam in the Georges Creek district. This seam, also known as Big Vein and Fourteen-Foot, originally supplied the bulk of the state production but is becoming depleted and increasing amounts are being mined from the Sewickley or Tyson seam. Other seams of less importance are the Davis or Freeport, the Piedment, Barton, Montell or Kittanning and Bakerstown or Thomas.

Geologically, the coal-bearing rocks in Maryland are classified as in Pennsylvania, the Pittsburgh and Sewickley seams occurring in the Monongahela group and the less important seams scattered through the Conemaugh and Allegany groups.

Maryland coals, as characterized by the Pittsburgh and Sewickley coals of the Georges Creek district, are low-volatile fuels largely used for steam generation but suitable as domestic heating, railroad, byproduct, coking and smithing coals. Like similar low-volatile coals from Pennsylvania and West Virginia, the coal is soft and friable and is generally shipped as run of mine. Its moisture and sulphur content is usually low and the fusion temperature of the ash is high, ranging from 2700 to 3000 F. These coals are best burned on underfeed stokers or in pulverized form and make excellent fuel for commercial steam generation.

TABLE 1
BITUMINOUS COAL PRODUCTION
1927 - 1932

	1927	1929	1931	1932
State production				
million tons	2815	2650	2005	1429
Per cent				
Allegany county	73.5	69.6	67.5	64.9
Garrett county	26.5	30.4	32.5	35.1

Table II gives typical analyses of coals from the various seams and districts. The moisture and ash values are on an as-received basis and the other values are moisture and ash free. This table shows the general variation in the composition of the coals in the different districts and serves as a reference from which a complete analysis may be set up when only the source of the coal is known. The analysis for the Pittsburgh and Sewickley seams are similar and since these two seams contribute the bulk of the state production their analysis represents the average Maryland coal.

TABLE II
TYPICAL INDIVIDUAL ANALYSES OF MARYLAND COALS

AS RECEIVED		MOISTURE AND ASH FREE							
MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	SULPHUR	HYDROGEN	CARBON	NITROGEN	OXYGEN	BTU PER LB
1. Georges Creek District - Allegany County									
Pittsburgh or Big Vein Bed									
2.4	7.4	21.1	78.9	1.2	4.6	88.5	2.1	3.6	15620
3.7	6.0	20.6	79.4	0.9	4.8	89.7	2.1	2.5	15640
1.2	7.7	19.7	80.3	1.0	4.8	88.9	2.1	3.2	15580
2.9	8.8	21.2	78.8	1.1	5.1	87.7	2.1	4.0	15660
2.2	7.3	20.9	79.1	1.1	4.9	89.5	2.2	2.3	15670
2.1	7.6	20.1	79.9	0.9	4.9	89.4	2.1	2.7	15640
Sewickley or Tyson Bed									
2.2	5.7	21.1	78.9	1.0	4.8	89.3	1.9	3.0	15660
3.2	8.2	20.5	79.5	1.1	4.7	89.1	1.8	3.3	15640
2.6	5.1	21.6	78.4	1.1	4.8	89.5	1.8	2.8	15680
1.3	8.4	22.3	77.7	1.2	4.9	87.9	2.0	4.0	15560
2.7	6.0	21.8	78.2	1.1	4.7	88.3	2.0	3.9	15600
Barton Bed									
2.3	9.9	19.9	80.1	2.5	4.6	88.7	1.9	2.3	15540
2.6	11.1	18.3	81.7	2.5	5.0	89.6	1.8	1.1	15570
1.3	10.6	17.7	82.3	2.4	4.5	89.0	1.6	2.5	15490
Montell or Upper Kittanning									
3.3	9.6	18.6	81.4	1.6	4.7	89.7	1.5	2.5	15550
3.2	15.5	20.0	80.0	1.7	4.7	88.7	1.5	3.4	15380
Piedmont Bed									
3.4	10.8	17.7	82.3	1.7	4.7	88.8	1.6	3.2	15600
1.9	10.0	17.7	82.3	1.8	4.6	89.3	1.6	2.7	15520
Davis or Upper Freeport Bed									
3.5	10.7	23.2	76.8	2.9	5.1	89.4	1.9	0.7	15600
2.9	8.3	22.4	77.6	1.5	5.1	88.8	1.4	3.2	15670
2. Upper Potomac District - Garrett County									
Bakerstown or Thomas Bed									
3.2	10.0	22.1	77.9	1.7	4.7	88.8	1.4	3.4	15500
2.6	16.4	20.6	79.4	1.7	4.6	88.7	1.5	3.5	15460
1.8	7.7	20.0	80.0	2.0	4.6	89.3	1.5	2.6	15680
Upper Freeport or Davis Bed									
1.7	9.9	20.9	79.1	1.8	4.6	88.6	1.2	3.7	15610
2.4	9.4	18.6	81.4	2.3	4.7	89.0	1.5	2.5	15540
1.8	10.0	18.7	81.3	2.8	4.6	89.2	1.5	1.9	15880
Piedmont Bed									
3.1	11.7	17.2	82.8	2.4	4.5	89.4	1.5	2.2	15530
3.6	8.4	18.5	81.5	0.7	4.5	89.9	1.6	3.3	15600
3. Castleman and Youghiogheny Districts - Garrett County									
Upper Freeport or Davis Bed									
2.7	10.7	26.5	73.5	2.4	5.2	87.4	1.6	3.4	15480
3.3	8.0	24.7	75.3	1.3	4.8	88.3	1.6	4.0	15530
Piedmont Bed									
4.3	7.7	24.9	75.1	2.9	4.9	87.7	1.7	2.8	15480
Kittanning Bed									
3.6	11.4	27.0	73.0	4.7	5.1	86.2	1.5	2.5	15460

TABLE III
AVERAGE ANALYSES FOR MARYLAND COALS

1. Georges Creek District - Allegany County

	As Received	Dry	Moisture and Ash Free
Moisture	2.5	-	-
Ash	8.0	8.21	-
Volatile Matter	18.80	19.28	21.0
Fixed Carbon	70.70	72.51	79.0
	100.00	100.00	100.0
Sulphur	0.98	1.01	1.1
Hydrogen	4.30	4.40	4.8
Carbon	79.57	81.60	88.9
Nitrogen	1.79	1.84	2.0
Oxygen	2.86	2.94	3.2
	89.50	91.79	100.0
Btu per lb.	13980	14335	15620

2. Upper Potomac District - Garrett County

	As Received	Dry	Moisture and Ash Free
Moisture	2.5	-	-
Ash	9.5	9.74	-
Volatile Matter	17.16	17.60	19.5
Fixed Carbon	70.84	72.66	80.5
	100.00	100.00	100.0
Sulphur	1.67	1.71	1.9
Hydrogen	4.05	4.15	4.6
Carbon	78.41	80.42	89.1
Nitrogen	1.32	1.35	1.5
Oxygen	2.55	2.63	2.9
	88.00	90.26	100.0
Btu per lb.	13730	14080	15600

3. Castlemen and Youghiogheny Districts - Garrett County

	As Received	Dry	Moisture and Ash Free
Moisture	3.5	-	-
Ash	9.5	9.84	-
Volatile Matter	22.19	22.99	25.5
Fixed Carbon	64.81	67.17	74.5
	100.00	100.00	100.0
Sulphur	2.44	2.52	2.8
Hydrogen	4.35	4.51	5.0
Carbon	76.04	78.80	87.4
Nitrogen	1.39	1.44	1.6
Oxygen	2.78	2.89	3.2
	87.00	90.16	100.0
Btu per lb.	13475	13965	15490

In Table III, average analyses of coal from the different districts have been set up for assumed moisture and ash values. These may be used in absence of more specific information and for Maryland coals in general the analysis given for Georges Creek district is applicable.

The New York Power Show

Increased power loads, accumulated obsolescence of depression years and acceleration of new development to meet present trends should combine to make the forthcoming New York Power Show most successful, both as to attendance and as to the equipment displayed. It is understood that steam generating equipment and accessories will again constitute a comprehensive section, comparable to its place in the 1929 Show.

Equipment such as is being employed in some of the recent high-pressure installations will be shown, where space permits, and illustrated where it does not. Microscopic demonstrations will indicate problems of welding pipe and certain manufacturers will feature alloys and the processes by which they are made. One company will show a working model of a 79-in. hot strip mill. Also, the display of instruments, control equipment and refractories promises to hold unusual interest.

The Law as Applied to Trade-Marks and Trade Names

By LEO T. PARKER,
Attorney, Cincinnati, O.

What constitutes a trade-mark, what trade-marks may be registered and how, comparison of infringing marks, the difference between trade-marks and trade names, and the right to use one's own name are discussed in the light of numerous court decisions with a view to enabling manufacturers and engineers to avoid costly litigation through thoughtless infringement.

LEGALLY, a trade-mark is a name, mark or other distinctive symbol which indicates the origin of the merchandise, product or service to which it is affixed. In other words, the primary object of adopting a trade-mark is to establish in the minds of the public the quality and kind of product or service the mark represents. It is not, as many persons believe, the name of the plant or business. A name of a business, or manufacturing plant, is a trade name which is quite different from a trade-mark. For instance, the Supreme Court of the United States, in the leading case of *Company V. Trainer, 101 U. S. 51,* clearly explained the legal status of a trade-mark as follows:

"Everyone is at liberty to affix to a product of his own manufacture and symbol or device, *not previously appropriated,* which will distinguish it from articles of the same nature manufactured or sold by others, and thus secure to himself the benefits of increased sale by reason of any peculiar excellence he may have given to it. The symbol gives assurance to the public of the origin of the goods to which it is attached, and an assurance that they are the genuine articles of the original producer.... The Courts will protect him in its exclusive use, either by the imposition of damages for its wrongful appropriation, or by restraining others and compelling them to account for profits made on a sale of goods marked with it."

What Trade-Marks May Be Registered

The trade-mark laws provide for registration of any distinctive name or symbol of a saleable article sufficiently different in *all* respects from marks previously registered so that use of the new mark will not interfere with the trade and good will of the owners of other marks. The fundamental reason for this law is to safeguard purchasers against being confused by similarity of the new and old marks.

Therefore, since a trade-mark is intended to indicate the origin of merchandise, products or service, it is legally the exclusive property forever of the one who registers it. In the United States a trade-mark issues for twenty years and it may be renewed indefinitely every twenty years. The only requirement for renewal is that the owner shall continue to use the name or mark in the business to which it is applied.

Henceforth, to acquire the right to the exclusive use of a trade-mark, the owner must show that the mark was adopted for the purpose of identifying the origin of his product and that the exclusive right to use the mark is founded on priority in interstate use. In other words, a trade-mark cannot be registered unless the mark has been used on merchandise or products shipped, mailed or delivered from the plant to persons who live in another state.

One of the chief advantages gained by registering a trade-mark is that the plant owner is permitted to resort to the United States Courts to prevent infringement. Also, he is given the exclusive right to use the mark in all parts of the United States, although he may do business in only a small interstate area.

The law is well-established that a valid trade-mark must be based upon true facts and not have connected therewith any deceit or falsity.

Generally speaking, any trade-mark, although it is descriptive, that has been used in bona fide interstate, or foreign or Indian tribe commerce may be registered by its owner, except those marks which contain immoral matter; or the flag or coat of arms or insignia of the United States or any state or city or foreign country; or a picture adopted or used by any fraternal society; or the name, distinguishing mark or emblem or the like of any club, society or organization.

Also, a mark which consists of the insignia of the American Red Cross Society cannot be registered. If the mark is *descriptive* of the product it represents, or if it is a geographical name, or if it is a signature, it should be registered under the Act of March 19, 1920. A mark which describes the quality of a product cannot be registered until the owner has used it for more than one year.

Of course, no trade-mark may be registered which is similar to another mark previously registered by another manufacturer. However, the fact that the trade-mark desired to be registered is identical or similar to another trade-mark previously registered and used on goods of a different classification, will not prevent the owner from registering the mark.

Obviously, an owner may use his own name as his trade-mark and usually he may without difficulty obtain registration of this trade-mark.

Comparison of Infringing Marks

Broadly speaking, in determining whether one trade-mark infringes another, the two important things for consideration are: (1) Is there likelihood of the original user of the mark suffering financial loss as a result of the similarity of the mark adopted by a competitor? (2) Is

the buying public likely to be deceived by the use of the new mark?

The Courts are unanimously of the opinion that the user of a name of merchandise shall not in any manner directly or indirectly profit from money expended by the owner of a previously established trade-mark. Furthermore, the Courts safeguard purchasers against being deceived by use of an infringing trade-mark.

For instance, in commenting upon the methods of determining whether one mark infringes another, in *McLean vs. Flaning, 96 U. S. 245*, the United States Supreme Court, said:

"Much must depend, in every case, upon the appearance and special characteristics of the entire mark, but it is safe to declare as a general rule, that exact similitude is not required to constitute an infringement or to entitle the complaining party to protection. If the forms, marks, contents, words or the special arrangement of the same, or the general appearance of the alleged infringer's device, is such as would be likely to mislead one in the ordinary course of purchasing the genuine article, then the similitude is such as entitles the injured party to protection."

It is interesting to observe that the higher Courts held the following names of well-known articles infringed. Therefore, if either of the following marks is now being used as a trade-mark, another owner cannot register the similar trade-mark for use on the small class of merchandise.

Trade-Mark	*Held Infringed by*
D	B
New Process	New Prospect
Queen Quality	Queen
Beats-All	Know-All
Excelsior	Excellent
Stark	Star
Economy	Economic
Normal	Normandy
Peaks	Alps
55	35

Various other higher Courts have held that "Warranty" does not infringe "Bond"; and "New Era" does not infringe "New Departure."

Right to Use Own Name

Many believe that a plant owner may not be prevented from using his own surname as a trade-mark or as a trade name. However, it is interesting to observe that the Courts have held on numerous occasions that although no person may be restrained from a legitimate use of his own name, he will be prohibited from using it unfairly, as where it has been used in the same locality by another person or firm.

In many cases it has been held that a person who uses his own name for a trade-mark, which is similar to a mark previously registered, is required to print a notification on his product to warn the public against deception. If, however, use of the name is not likely to result in deception the situation is different.

For illustration, in the leading case of *Brown Co. vs. Meyer, 139 U. S. 540*, the Supreme Court of the United States said:

"A man's name is his own property, and he has the right to its use and enjoyment as he has to that of any other species of property. If such use be a reasonable, honest and fair exercise of such right, he is no more liable for the incidental damage he may do a rival in trade than he would be for injury to his neighbor's property by the smoke issuing from his chimney."

In the majority of cases where persons, using their names as trade-marks, have been held liable as infringers convincing proof to the satisfaction of the Court was introduced showing that the new trade-mark was adopted purely with intent to deceive the public and unfairly acquire profits from the publicity previously acquired by the owner of the established trade-mark.

How to Register a Trade-Mark

Almost all owners who obtain registration of trademarks use the services of a competent patent lawyer located in the city or town in which the plant is situated. A conservative fee, including all expenses, is $50. However, by following the rules laid down by the United States Patent Office, an owner may himself register his trade-mark. Address, "The Commissioner of Patents, Washington, D. C.," and request a booklet on how to register a trade-mark. From this booklet may be copied the Petition-Statement and the Oath, both of which the owner must sign, as directed. Also, a drawing must be made in India ink and it must show the exact duplication of the adopted trade-mark. It must be signed by the owner, or his patent lawyer. The drawing, Petition-Statement and the Oath, together with $15 Government fee, must be mailed to "The Commissioner of Patents, Washington, D. C."

NEW CATALOGS AND BULLETINS

Any of the publications will be sent on request.

Air-Operated Controller

The Brown Instrument Company, Philadelphia, has just issued a new catalog, No. 8901, covering its complete line of air operated controllers for the control of temperature, pressure, flow and liquid level. It explains in simple, non-technical language the principle of operation and contains numerous diagrams illustrating their construction.

Automatic Valves

Davis Regulator Co., Chicago, has recently issued a 32-page booklet describing the design, construction and operation of its pressure regulators, controllers, stop valves, balanced relief valves, altitude valves, pump governors and strainers.

Axial-Flow Impulse Turbine

Bulletin S-107 issued by the Terry Steam Turbine Company, Hartford, Conn., describes the various features of its axial-flow impulse design, made in six types, four of which have two rows of moving buckets and two, three rows. These turbines are suitable for driving pumps, fans, exciters, generators, paper machines, etc., and may be connected to the driven machine either directly or through reduction gears. The design is particularly adapted to high temperature service.

Chain Drives

The Morse Chain Co., Ithaca, N. Y., has issued a 48-page catalog describing its line of silent chain drives and couplings. It includes numerous tables giving dimensional, power and price data on chains, flexible couplings, sprockets, etc., and is fully illustrated.

Coal, Ash and Cinder Handling

"Modern Methods for Ash and Soot Disposal, Cinder and Fuel Reclaiming Systems, Coal Conveying, Ash-Storage Tanks and Durite, a Wear-Resisting Metal," is the title of a binder, containing a set of informative and splendidly illustrated catalogs on these respective items, which has been issued by United Conveyor Corporation, Chicago. The "Nuveyor" heavy-duty ash conveying system, described in one of these catalogs, is a pipeline system employing air as the transporting medium, whereas that covered by another of the catalogs is a hydro system for the dustless disposal of ash and soot. A third catalog deals with two methods of reclaiming cinders—one, by returning the cinders to the coal bunker and the other by returning the cinders directly to the furnace. The development and characteristics of "Durite," the metal used in these systems, are covered at length.

CO_2 Meters

Data Book No. 403, lately issued by the Republic Flow Meters Co., Chicago, contains complete specifications covering the construction, principles of operation and application of the line of CO_2 meters made by this company. This includes indicator, recorder, indicator-recorder, recorder-integrator and indicator-recorder-integrator types. Draft and pressure indicators are also included. Boiler efficiency and the causes of inefficient combustion are also discussed.

Dowtherm

"Dowtherm for High Temperature Heat Transfer Systems," is the title of a 36-page publication just issued by the Dow Chemical Company of Midland, Mich., containing a digest of data collected on this product during the past eight or ten years. Among the topics covered are, the fields of application, thermal efficiency, methods of heating the Dowtherm, pipe sizes and pressure drops, calculations of heat transfer coefficients as applied to both the liquid and the vapor, and servicing Dowtherm systems. Charts, curves, formulas and diagrams are included as part of the technical information.

Electric Flow Meters

Electric flow meters for remote measurement of steam, water, gas and other fluids are covered in publication No. 2096 issued by the Cochrane Corporation, Philadelphia. The galvanometer Null principle of measurement is explained and the several styles of instruments adapted to different applications are described.

Hot Process Water Softener

A new publication, No. 2059, just issued by the Cochrane Corporation of Philadelphia describes the deaerating type of Cochrane hot process water softener and reviews the progress made in so combining the deaerating and softening elements as to give a simplified arrangement, low installation and maintenance cost and small space requirements.

Insulations

The 1936 edition of the Johns-Manville Industrial Products Catalog is now available. This 60-page book, profusely illustrated, contains detailed information and recommendations on high and low temperature insulations for every industrial need. Among new products described are Transite Korduct, a thin-walled form of asbestos-cement electrical conduit; Rock Cork Pipe Covering, a mineral insulation for low temperature piping, and J-M Ohmstone, a non-impregnated asbestos-cement sheet for switchboard panels that will stand shock and vibration and is immune to carbonization.

Motors

The General Electric Company, Schenectady, N. Y., has just issued four new bulletins describing, respectively, its latest lines of general-purpose squirrel-cage induction motors, Type K induction motors, splash-proof induction motors and explosion-proof induction motors, the last named being totally enclosed and fan-cooled. The applications of each are fully discussed.

Steam Trap

"What Makes the Yarway Steam Trap Work," is the title of an interesting 4-page circular being distributed by Yarnall-Waring Co., Philadelphia. Colored sectional views through the trap assist materially in obtaining a clear understanding of its operation.

Thermocouple Pyrometers

A new 52-page catalog, well illustrated and written in simple non-technical language, has been issued by Leeds & Northrup Company, Philadelphia, describing its line of "Macromax" thermocouple pyrometers. The potentiometer method of measurement is explained and various applications are dealt with. Data on dimensions and standard ranges for the various models are included.

Valves

Two new bulletins have just been issued by the Hancock Valve Division of Consolidated Ashcroft Hancock Company. One describes the new "Flocontrol" Valve—the first manually operated valve with a straight-line flow characteristic and the other gives details on the new Hancock Union Bonnet Bronze Valve—a valve with stainless steel trim that is claimed to resist steam cutting and wire drawing.

Vibrating Screens

A new 24-page illustrated catalog No. 1562, complete with clearance diagrams and dimension tables, has been issued by Link-Belt Company, Chicago, on the company's two distinct types of vibrating screens ("UP" and "PD") for screening various materials including coal. The "UP" unbalanced-pulley type screen is intended for handling free-screening materials at moderate capacities, for work requiring high speed vibration, and for close sizing problems requiring comparatively small screen openings. The "PD" positive drive type heavy-duty screen is recommended for the larger screen openings and heavier capacities.

STEAM ENGINEERING ABROAD

As reported in the foreign technical press

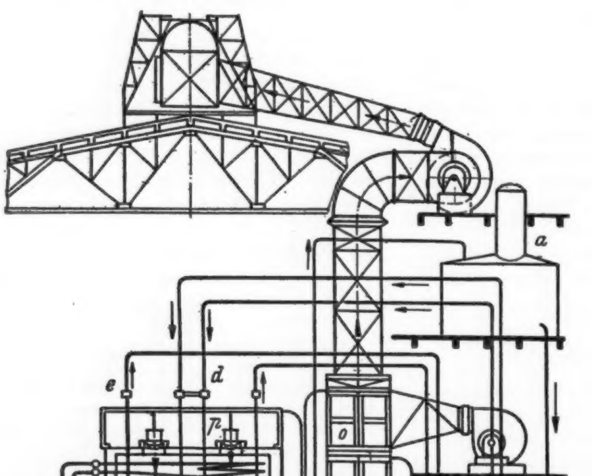
The Ramsin High-Pressure Boiler

The first published description of the Ramsin[1] high-pressure boiler appears in the September issue of *Wärmewirtschaft* as a translation from a recent Russian paper.

This boiler is of the small-tube, forced-circulation type, rated at 440,000 lb per hr maximum with steam at 2100 lb per sq in. and 900 to 932 total steam temperature. The boiler is designed for pulverized coal firing but is being operated with oil and has been in service since December 20, 1933. The steam after passing through the high-pressure turbine is reheated before being admitted to the low-pressure turbine. Incidentally, this is the first forced-circulation, high-pressure boiler designed and built in the U.S.S.R.

As may be seen by reference to the diagrammatic sketch, the radiant heating surface consists of four sets of tube banks, surrounding the furnace and connected so as to secure a balanced effect. The convection heating surface consists of the superheater, economizer, reheater and air heater. The tubes of the radiant sections are, respectively, $1^{1}/_{4}$ and $1^{1}/_{8}$ in. at the entrance and increase to $1^{5}/_{8}$ and $2^{1}/_{8}$ at the exit. A floor screen is also provided.

[1] Professor Ramsin is a well-known Russian engineer, known to many Americans who attended the earlier World Power Conferences and whose trial a few years ago attracted wide attention. He is now understood to be a political prisoner in Russia.



Diagrammatic Sketch of Ramsin Boiler

a, deaerating heater; *b*, main feed pump; *c*, bleeder heaters and high-pressure feed pump; *d*, headers; *e*, hanger tubes; *f*, economizer; *g*, radiant water-heating section; *h*, upper radiant heating section; *i*, lower radiant heating section (superheating coils); *k*, ash hopper; *l*, convection superheater; *m*, header; *n*, reheater; *o*, air heater; *p*, burners.

The condensate after passing through a deaerating heater *a* is forced by the feed pump *b* through the bleeder heaters *c* to 24 hanger tubes supporting the radiant heating surface in the furnace. From here it passes to the economizer sections *f* and then to the upper radiant sections, thence to the lower sections where some superheating takes place and finally to the convection superheater *l*. The reheater is indicated by *n*. Thus it will be seen that, unlike the present Benson design, the transition stage from water to steam occurs in the radiant section.

The steam pressure is regulated by hand by means of remote control; the draft has automatic regulation; and excessive rise or fall in steam temperature is indicated by light and sound signals. In operation it has been found that the boiler cannot be run below 66,000 lb per hr (15 per cent full load) because the individual coils are likely to become overheated. To overcome this situation resistances in the form of nozzles, or diaphragms, of different diameters are being placed in the headers at the beginning of each coil before the inlet into the upper and lower radiant sections.

The average gross operating efficiency for 1935 was 84.1 per cent with loads varying between 132,000 and 176,000 lb per hr. This corresponds to a net efficiency, deducting the power of auxiliaries, of 81.4 per cent.

Large Cooling Tower

The Kearsley power station of the Lancashire Electric Power Company has just installed what is claimed to be the largest cooling tower yet constructed. Situated on the banks of the Irwell River, it is 250 ft high, has a diameter of 175 ft and has been designed to cool three million gallons of water per hour. The complete tower weighs about five thousand tons. An order for a second tower of similar dimensions has been placed.—*Industrial Britain*, September 1936.

Low Temperature Carbonization

In the paper by F. Müller, entitled "Low-Temperature Carbonization of Coal," presented at the recent Chemical Engineering Congress, and reported in *Engineering* of September 4, the German experience with this subject was discussed. The difficulties encountered were not due solely to the design of plant, but also to the suit-

ability of the coal for low-temperature carbonization. The greatest importance was attached to the recognition of the fact that, in order to obtain low-temperature coke of the highest quality, in conjunction with a maximum yield of low-temperature tar and other products, the coal to be subjected to the treatment must be carefully selected in accordance with chemical and petrographic principles, while the bulk density of the coal and its grain size must also be given due consideration. For carrying out the process itself the author formulated the following four requirements: carbonization at rest; carbonization in thin layers; use of iron as a material of construction; and maximum heat economy through the use of an appropriate system of heating to obtain the maximum heat transfer at the low working temperature used in the process. The author considered low-temperature carbonization as a valuable method of refining coal, provided always that the process adopted was so thoroughly developed, in regard to heat economy and design of plant, that it enabled the main products, semi-coke and tar, of the best quality to be obtained economically, and provided that the solid fuel market were able to absorb the semi-coke produced.

British to Erect New Station in Kent

The Southeast England Electricity Plan, adopted by the Central Electricity Board in 1928, provided for the erection of four new steam stations. Of these Battersea and Fulham have been built and the rapidly increasing electric load has made necessary plans for a third new station near Dartford, Kent, to be operated by the Kent Electric Power Company. The first section of this station will comprise 120,000 kw and will probably consist of one 60,000-kw and two 30,000-kw turbine-generators supplied by six 250,000 lb per hr boilers. The steam conditions have not as yet been announced.—*Engineering*, London, September 18, 1936.

High-Pressure Marine Boiler

According to the July issue of *The Far Eastern Review*, the steamer "Kertosono" of the Rotterdam Lloyd service has recently been fitted with a high-pressure steam generator of the Sulzer monotube type, which has replaced one of the existing low-pressure Scotch boilers and has increased the vessel's speed by two knots. This boiler is designed for a pressure of 850 lb per sq in. and a total steam temperature of 700 F. A high-pressure geared turbine has been added, exhausting to the low-pressure turbines.

Large Paper Mill Power Plant

Large industrial power plants are by no means confined to the United States and Germany. One of the largest installations of this kind is the Kemsley Paper Mills near Sittingbourne, Eng., described in the August issue of *Engineering and Boiler House Review*. It has a boiler plant capacity of 1,110,000 lb of steam per hour and an aggregate turbine-generator capacity of 56,000 kw. While some of the older boilers are relatively small, the four latest are each of 110,000 lb per hr capacity. They are of the three-drum, bent-tube type, equipped with economizers and fired by traveling grate stokers. They are designed for 400-lb pressure but operate at 360 lb and 720 F steam temperature.

★ ★ ★ BOOKS ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

1—Oil Heating Handbook

By Han A. Kunitz

456 pages $5^1/_2 \times 7^3/_4$ $3.50

This comprehensive manual will be of interest to every man who designs, installs, sells or uses oil heating equipment. It answers the many questions home owners ask about oil heating, explains thoroughly and impartially the principles, installation and maintenance of oil burners, and provides students, oil burner men, as well as home owners, with concise definitions of words used in connection with heating engineering.

Starting off with a short introductory chapter and a description of a typical oil burner installation, the book is divided into four main divisions: *Fuels* and *Combustion; Heating* (including Operative Controls); *Installation* and *Operation*; *Retail Selling*.

The book is profusely illustrated and contains many valuable charts and tables.

2—Contracts in Engineering

By James Irwin Tucker

341 pages 6×9 $4.00

This book is intended to familiarize the engineer with certain legal principles encountered in business transactions, especially a thorough knowledge of contracts and certain rules underlying the writing of specifications. Chapters are included on "real property" and on "corporate and partnership law." Arranged primarily as a textbook for engineering students, the book should prove very useful as a reference for engineers.

3—Welding Technology and Design

By G. F. P. Fox and F. Bloor

90 pages $1.50

The text is divided into five parts, covering methods of welding and factors determining the use of arc welding; welded joints and strengths; metallurgical and mechanical features; plant and accessories; and applications to structural, electrical, automotive work, ship-building and general engineering. It presents a clear introduction to this growing art and the increasing practice of welding. Many useful tables and illustrations are included.

4—Men, Money and Molecules

By William Haynes

214 pages $7^1/_2 \times 5$ $1.50

This is a dissertation on the growth of the chemical industry, particularly in this country, its many ramifications, the role that it plays in the production of innumerable commonplace commodities and its contribution to the creation of new industries. That the chemical industry is basic to our every-day needs is shown by the fact that even in the darkest period of the depression its production stood at 77 per cent of the 1929 peak, compared with 41 per cent for steel and 36 per cent for automobiles. Appended to the text is a chronological listing of important American chemical developments.

The book is written in a non-technical and entertaining style and is highly informative.

5—Boiler Feed Water Treatment

By F. J. Matthews

256 pages $5^1/_2 \times 8^3/_4$ $5.00

This book not only covers the well-established processes of water softening and the usual methods of control, but it also gives an easily understood account of the newer methods of treating boiler feed waters which have been developed during the past ten years. These latter are designed to prevent scale formation, in particular in modern high-pressure boilers, where a water softened by the ordinary lime-soda process is in use.

The introductory chapters follow conventional lines. The characteristics of various natural boiler waters are described. The chemical principles of lime-soda water softening are then discussed, and a short account given of the constructional features and methods of operation of lime-soda plants. The beneficial action of sodium aluminate as a softening agent is explained in that a reduction is effected of the "residual hardness" of a lime-soda softened water, the formation of flocculent precipitates facilitates rapid sedimentation and filtration and the formation of silicate scale is retarded if not entirely prevented. Short sections are devoted to zeolite softeners, the treatment of alkaline waters, the use of condensate as feed-water, and water blending and lime-barium softening. The mechanism of scale formation and the meaning and purpose of carbonate and phosphate conditioning are well and simply presented.

The foregoing matters are dealt with in the first 96 pages of the book. The remainder of the volume is divided into separate sections devoted, in turn, to corrosion, foaming and priming, and analysis and routine testing.

6—Mechanics of Materials

By S. G. George and E. W. Rettger

483 pages Price $3.75

This is a simple yet comprehensive treatment of elementary mechanics of materials, written primarily for students in engineering. The book, although presupposing a limited knowledge of calculus, should also serve as a convenient reference for the practicing engineer who may be a bit rusty in this branch of mathematics. References are also given to more advanced treatises on the subject and the arrangement of the text is such that any or all of the advanced topics may be eliminated without loss of sequence in the more elementary portions. One of the distinctive features of the book is the inclusion of material on the slope deflection method for finding the deflection of a beam and the reactions of a statically intermediate beam.

7—Steam Plant Operation

By Everett B. Woodruff and Herbert B. Lammers

368 pages $5^1/_2 \times 8$ Price $3.00

The purpose of this book is to present a combination of technical and practical information on the fundamentals of stationary power plant practice and to serve as a reference in preparation for attaining an operator's license. The authors have had both operating and teaching experience and are thus in a position to understand the point of view and needs of the practical man. The text is arranged for either home study or class-room use.

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EQUIPMENT SALES

Boiler, Stoker, Pulverized Fuel

as reported by equipment manufacturers of the Department of Commerce, Bureau of the Census

Boiler Sales

Orders for 179 water-tube and h.r.t. boilers were placed in August

	Number	Square Feet
August, 1936	179	621,644
August, 1935	87	254,810
January to August (inclusive, 1936)	1,086	3,790,357
Same period, 1935	647	2,092,167

NEW ORDERS, BY KIND, PLACED IN AUGUST 1935–1936

	August 1936		August 1935	
Kind	Number	Square Feet	Number	Square Feet
Stationary:				
Water tube	121	534,525	56	218,463
Horizontal return tubular	58	87,119	31	36,347
	179	621,644	87	254,810

Mechanical Stoker Sales

Orders for 434 stokers Class 4* totaling 80,268 hp were reported in August by 46 manufacturers

	Installed under			
	Fire-tube Boilers		Water-tube Boilers	
	No.	Horsepower	No.	Horsepower
August, 1936	336	45,960	98	34,308
August, 1935	193	24,298	76	23,057
January to August (inclusive, 1936)	1,356	180,862	410	173,207
Same period, 1935	875	116,866	371	142,782

* Capacity over 300 lb of coal per hr.

Pulverized Fuel Equipment Sales

Orders for 34 pulverizers with a total capacity of 311,300 lb per hr were placed in August

STORAGE SYSTEM

	Pulverizers				Water-tube Boilers		
	Total number	No. for new boilers, furnaces and kilns	No. for existing boilers	Total capacity lb coal per hour for contract	Number	Total sq ft steam-generating surface	Total lb steam per hour equivalent
August, 1936	..	..	..	.....	None	None	None
August, 1935	..	..	..	.....	..	....	....
January to August (inc. 1936)	..	..	..	.....	..	....	....
Same period, 1935	..	..	..	.....	..	....	....

DIRECT FIRED OR UNIT SYSTEM

	Pulverizers				Water-tube Boilers		
August, 1936	29	18	11	304,500	20	321,291	2,483,500
August, 1935	17	8	9	79,550	15	78,384	762,580
January to August (inc. 1936)	197	144	53	2,034,400	137	1,360,948	18,081,500
Same period, 1935	79	43	33	369,310	67	371,737	3,369,160
					Fire-tube Boilers		
August, 1936	2	..	2	800	2	3,000	8,000
August, 1935	..	..	..	.....	..	....	....
January to August (inc. 1936)	19	3	16	22,900	19	40,600	233,850
Same period, 1935	3	..	3	3,300	3	6,130	32,500

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